**ISRO-HQ: SP:78: 2004**
**CONFERENCE REPORT**

# INDIA – UNITED STATES CONFERENCE ON SPACE SCIENCE, APPLICATIONS AND COMMERCE —*STRENGTHENING AND EXPANDING COOPERATION*

June 21 – 25, 2004
Bangalore, India

Organized by:

**Astronautical Society of India (ASI)**
**&**
**American Institute of Aeronautics and Astronautics (AIAA)**

**Sponsored by:**

INDO-US SCIENCE AND TECHNOLOGY FORUM

इसरो ISRO

**Co-sponsored by:**

NASA

NOAA

BOEING

Raytheon

NORTHROP GRUMMAN

Honeywell

JB BODA

NEW INDIA ASSURANCE

**Organized by:**

**ASTRONAUTICAL SOCIETY OF INDIA**

AIAA

American Institute of Aeronautics and Astronautics

**Space exhibition organized by:**

MM ACTIV

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# MESSAGES

## Message from Dr. Manmohan Singh, Prime Minister of India

I congratulate the Indian and U.S. organizers of this Conference on Space Science, Applications and Commerce. It would perhaps surprise many that we are marking four decades of cooperation in space-related activities between India and the United States. I am pleased that the Conference has drawn an enthusiastic response from representatives of Government, business and industry of both countries.

India is no stranger to the exploration of space and in fact has actively embraced it. Our space programme, nurtured and strengthened over the past 40 years, is today one of our national treasures. Over the years, the impact of space applications has multiplied manifold; today it is intricately woven into the daily lives of our people. Indian space systems — the INSAT and the IRS — are at the core of our capabilities in telecommunication, television broadcasting and national natural resources survey. They are also important instruments for extending the benefits of education and health services to rural areas, for the management of natural resources, for disaster management support and for environmental monitoring. India is a world leader in remote sensing and its applications. Our satellite launch capabilities can hold their own in a commercially competitive environment. This is an attribute of national development that we are truly proud of.

Cooperation in space science and applications between India and United States goes back to the landmark SITE experiment in education in 1975, which demonstrated the use of satellites for providing education in remote areas. Today, this cooperation has expanded to exchange of meteorological data and cooperation in the area of earth and atmospheric sciences. Indian-origin scientists work in substantial numbers across a spectrum of American space establishments, including at NASA. As two space-faring nations, the sky is no longer the limit of our cooperation.

India and the United States recognize that there is vast scope for bilateral high technology commerce — including civilian space commerce. Strong economic ties in high technology based on mutual trust can greatly supplement our shared values and political interests in providing an enduring foundation for a strategic partnership. While our two governments are taking steps to create the appropriate environment for successful high-technology commerce, this Conference would help in identifying and generating an awareness of market opportunities. It can also contribute to building additional confidence between the two countries for such cooperation, in a way that reflects their transforming relationship and common interests.

I compliment the organizers for holding this Conference and wish it success.

June 17, 2004
(Manmohan Singh)
Prime Minister of India
Prime Minister's Office
New Delhi

## Message from Mr. George W. Bush, President, United States of America

I send greetings to those gathered to participate in the India-United States Conference on Space Science, Applications and Commerce.

India and the United States share a history of more than four decades of cooperation in space. Our risk-takers and visionaries have expanded human knowledge, revolutionized understanding of the universe, and produced technological advances that have benefited all of humanity. This conference gives participants an opportunity to identify new opportunities for civil space cooperation to answer scientific questions, improve the quality of life for others, and inspire the next generation to explore our universe.

I applaud conference participants for your commitment to excellence in science and technology. Your efforts strengthen the bilateral relationship between the United States and India and reflect our common spirit of discovery and innovation.

Laura joins me in sending our best wishes.

June 17, 2004
George W. Bush
President, United States of America
The White House
Washington, DC

## Message from Mr. G. Madhavan Nair, Chairman of ISRO and President, Astronautical Society of India

A very warm welcome to all of you to Bangalore and to the India-United States Conference on Space Science, Applications and Commerce.

The Indian space programme, evolved over the last forty years, has contributed in a major way towards the national development. India has demonstrated the use of space in a variety of societal applications. They include broadcasting and communication services to rural areas, management of natural resources, monitoring of environment, improving education and health services, supporting disaster management among many others. The Indian National Satellite (INSAT) and Indian Remote Sensing Satellite (IRS) systems along with the operational satellite launch vehicles — PSLV and GSLV — have become a mainstay of the national development process. Self-reliance and indigenous development have been the hallmark of the Indian space programme to provide cost-effective solutions towards meeting our envisaged goals.

The genesis of this Conference lies in the joint vision of the Prime Minister of India and the President of the United States of America in 2001 calling for enhancement in civil space cooperation and increased high-technology trade between the two countries. The sponsors and organizers of this conference have been working for many months to make this event happen. For the first time, this Conference brings together a large number of scientists, industry representatives, policy-makers, high-level government officials and academicians from India and the United States of America on one platform to discuss and debate potential collaborative and business opportunities.

Both The United States and India have a successful history of space activities and their own strengths. There have also been many instances of successful cooperation. This background augurs well for exploring future cooperative and collaborative ventures for mutual benefits. To exploit such opportunities, there is a need to move forward with a focused vision, concrete strategy and determination to tackle the challenges ahead. I do hope that this conference would be a major step in this process.

The Joint Programme Committee has worked out a well-knit programme for the Conference with over 150 talks in various major themes. I sincerely hope that you would find the programme to be interesting and thought provoking.

Bangalore, the Aerospace and Information Technology hub of India, has many wonderful facets and an ancient history with a judicious mix of modernism and traditional culture. I hope you will find time to explore and experience Bangalore and its people.

On behalf of ISRO and ASI, I wish you all a comfortable and pleasant stay in Bangalore and a very fruitful path-breaking Conference.

June 11, 2004
G. Madhavan Nair
Chairman, ISRO/Secretary, DOS

## Message from Dr. David C. Mulford, Ambassador of the United States of America to India

To All Conference Participants:

The United States and India have a common goal of building a strong and dynamic relationship based on shared values and interests. President Bush made it a priority of his administration to fundamentally transform the U.S.-India relationship to reflect these shared democratic values and interests and to dramatically enhance our bilateral cooperation in a number of areas.

When announcing the Next Steps in Strategic Partnership with India in January 2004, President Bush stressed that the United States and India had agreed to expand cooperation in three specific areas: civilian nuclear activities, civilian space programs, and high-technology trade. The U.S. and India also agreed to an enhanced dialogue on missile defense. These areas represent the cutting edge of technological science and technology development and can lay the foundation to dramatically enhance bilateral and commercial cooperation between our two great nations.

It is my great pleasure to welcome The India-United States Conference on Space Science, Applications and Commerce as an important step in bringing President Bush's vision of a transformed U.S.-India relationship to reality. This Conference represents an important milestone in the NASA–ISRO relationship which began 40 years ago with the joint launch of a Nike-Apache sounding rocket from Trivandrum in Kerala. Bringing together hundreds of leading U.S. and Indian commercial, scientific and government representatives to engage and challenge each other on how we can aggressively push our relationship forward in the area of space cooperation is a truly exciting opportunity.

International cooperation in space can help build stronger relations between countries, contribute to economic and social development, and expand the frontiers of human knowledge. In the United States alone, more than 1,300 different space technologies have helped save lives, contributed to U.S. industry, and improved the quality of life for the common person. India is pioneering the use of space technology for development through telemedicine and tele-education. Drawing on the advice and experience of government policy-makers, leaders in aerospace commerce and researchers in space science and technology from our two countries, we are confident this Conference will lay the foundation for continued commercial, development and research opportunities within our growing bilateral relationship. Through this Conference, President Bush's vision of U.S.-India strategic partnership is becoming a reality.

On behalf of the Government of the United States of America, I thank our co-sponsors, the Indian Space Research Organization and the Indo-U.S. Science and Technology Forum, as well as the American Institute of Aeronautics and Astronautics and the Astronautical Society of India, the co-organizers of the Conference — for their valuable contributions to the success of this important event.

June 8, 2004
David C. Mulford
U.S. Ambassador to India

# EXECUTIVE SUMMARY

# EXECUTIVE SUMMARY

India has come a long way in developing a multi-faceted and multi-dimensional space programme, which is indigenous, self-reliant and applications driven. India now builds its own state of the art satellites — Indian National Satellite system (INSAT) supporting national communications and broadcasting needs and Indian Remote Sensing System (IRS) — supporting national natural resources management, disaster management and environmental monitoring. India also has its own launch vehicles — Polar Satellite Launch Vehicle (PSLV) and Geo-synchronous Satellite Launch Vehicle (GSLV). Indian space products — transponders, remote sensing data etc have already become a part of global network.

The United States has a long history in space and has achieved many successes. Many a citizen's imagination has been ignited with the U.S. forays in space and many have found fascination with the intricate knowledge of space and earth that has been made possible by U.S. space systems. The US space industry is the largest in the world, supplying equipment and technology for its own space systems and those of many other nations. The President of the United States, George W. Bush, recently unveiled a new vision of space for the United States with a strategy to explore and colonize the Moon, Mars and farther beyond.

## Indo-U.S. Cooperation in Space

In fact, the beginning of Indian space activities was through an Indo-U.S. cooperation that saw the establishment of the Thumba Equatorial Rocket Launching Station (TERLS) – from where the first sounding rocket, the U.S. Nike-Apache was launched on November 21, 1963 to conduct ionospheric experiments over the earth's magnetic equator.

India conducted the one of world's largest sociological experiment in the mid-1970s, using space technology through the Satellite Instructional Television Experiment (SITE) for which NASA provided its Application Technology (communications) Satellite (ATS-6) over the Indian Ocean. This enabled the direct broadcast of educational programmes on agriculture, family planning, health and hygiene, etc. to TV sets in about 2,400 villages across six states of India. This experiment was the precursor to the establishment of the multipurpose INSAT system in the 1980s. At that time, India procured all the four satellites under the INSAT-1 series from a U.S. company and three of them (INSAT-1A, INSAT-1B, INSAT-1D) were also launched by U.S. launch vehicles.

Anuradha, an Indian cosmic ray payload, was flown aboard the U.S. Space Shuttle Challenger in 1985 with the objective of determining the composition and intensity of energetic ions from the sun and other galactic sources.

In the field of remote sensing, in early 1970s India partnered with the United States in carrying out infrared imaging to detect coconut wilt disease in Kerala. India also established the data reception station for receiving data from NASA's Earth Resources Technology Satellite (ERTS), later renamed as LANDSAT. A number of joint experimental projects in remote sensing were undertaken using the LANDSAT data, and these experiments led to the design and development of India's IRS system — data from that is now globally marketed by a U.S. company under a commercial arrangement with India.

As recently as 1997, the Department of Space (DOS) and the Department of Science and Technology (DST) on the Indian side and NASA and NOAA on the U.S. side signed a Memorandum of Understanding for joint research in earth and atmospheric sciences. Currently the United States and India are also partners in efforts to develop the understanding necessary to address human health, safety and welfare issues, to protect the global environment, and to achieve sustainable development.

## India-United States Space Conference

After a few years of quietude, India and the United States have renewed their desire to explore cooperation in space research and commerce activities. ISRO and the U.S. Department of State concurred that a high-level conference in India could act as a catalyst for strengthening cooperation and commerce. It is with this background that the India-United States Conference on Space Science, Applications and Commerce was organized in Bangalore June 21-25, 2004. The conference was sponsored by ISRO, the U.S. Department of State and the Indo-U.S. Science & Technology Forum and was co-sponsored by the U.S. National Aeronautics and Space Administration (NASA), the U.S. National Oceanographic and Atmospheric Administration (NOAA) and a number of space-based industries from the United States and India.

The conference brought together 550 delegates, of which about 150 were from the US. For some of the U.S. professionals, it was the first time that they were directly exposed to Indian space capabilities — especially the interfaces of the programme between ISRO, government agencies, private sector, non-governmental organizations and universities in India. The Indian delegates obtained first-hand information on advanced technologies for space from presentations made by U.S. speakers. A Space Exhibition was also organized where about 16 U.S. and 21 Indian organizations showcased their space technologies, products and services.

In the Closing Plenary of the Conference, a **VISION STATEMENT** was adopted calling for strengthening and enhancing cooperation and commerce in space between the two nations and identified a series of recommendations. The Vision Statement calls on governments, business enterprises and research institutions in both India and the United States to:

- Work together to leverage benefits of space capabilities of India and the United States and contribute to sustainable global economic growth and scientific advancement.

- Work together in the following areas:
    - Earth Observation Science, Technology and Related Applications — including natural resources management, meteorology, water cycle, atmospheric sciences, infrastructure etc.
    - Satellite Communications Technology and Applications — including tele-medicine, tele-education etc.
    - Satellite Navigation and Applications
    - Earth and Space Science — including Astronomy, Planetary Science and Solar-Terrestrial Science, etc.
    - Natural Hazards Research and Disaster Management Support
    - Education and Training in Space

- Explore promising opportunities for business development in the areas of Earth Observations, Satellite Communications and Satellite Navigation through possible collaborative business ventures serving national and global markets.

- Facilitate cooperation and commerce through a high-level mechanism involving key representatives of government, business, academic and other non-governmental organizations from the United States and India with a view to monitor and review progress on civil space collaboration between the two countries. Under the leadership of the U.S. Ambassador to India and the Chairman of ISRO, the mechanism is to be enabled in the coming months through meetings between the two sides.

The outcome of the Conference has been very positive and should enable closer ties between the two nations in civil space activities. The focus, in the coming days, will be on strong partnerships, business connections, research projects and potentially joint space missions. The initial steps for a long-term partnership in space have been envisioned; it is up to the space entities of India and the United States to ensure that the technological capabilities of both sides leverage greater advantages to the benefit of both nations.

# INTRODUCTION

# ABOUT THE INDIA-U.S. SPACE CONFERENCE

Space technology plays an ever-increasing role in the development of society and in the improvement of quality of life. Through the development and application of space-based telecommunications, remote sensing and research in space science, humankind is realizing the social, economic and commercial benefits of space. India and the United States have cooperated for 40 years in space technology and applications. Both nations have operational space programmes and carry out a variety of activities of relevance to their countries and the entire world. They each have a large industrial base supporting their respective space programmes with an interest in furthering commercial activities in space.

The Joint Declaration between the Prime Minister of India and the President of the United States, at the end of 2001, states that "the two sides should discuss ways to stimulate bilateral high-technology commerce" and that "the United States and India have a mutual interest in space and have agreed to initiate discussions on civil space cooperation". As a follow-up to this intent at the highest level of the two governments, the **India-United States Conference on Space Science, Applications and Commerce — Strengthening and Expanding Cooperation** was organized in Bangalore, India, June 21-25, 2004.

## OBJECTIVES

The governments of India and the United States have already begun discussing the expansion of space science, applications and commercial cooperation. Current cooperation lies in the exchange of data from meteorological satellites and joint projects in atmospheric science. Enhanced cooperation in these and other areas of space science and applications, such as earth observation, disaster management, search and rescue, tele-medicine, tele-education, satellite communication and satellite navigation is of interest to both countries. Additionally, opportunities exist to expand commercial activities of mutual benefit.

The Conference brought together U.S. and Indian scientists, policy-makers and the private sector to explore additional cooperation between the two countries. The conference provided a forum for the review of cooperative programs and exchange of technological and scientific information to promote greater commercial opportunities between the two countries.

## TOPICS

The topics covered in the Conference were as follows:

- Earth Observation Science, Technology and Applications (4 sessions)
  - EO Session–1: Earth Observation Science, Technology and Applications — Natural Resources, Water Cycle and Infrastructure
  - EO Session–2: Earth Observation Science, Technology and Applications — Meteorology and Ocean Sciences
  - EO Session–3: Earth Observation Science, Technology and Applications — Atmospheric Composition and Solar Radiation and Sun-Climate
  - EO Session–4: Earth Observation Commerce
  - EO Session–5: Natural Hazards Research and Disaster Management Support

- Satellite Communication Technology and Applications (3 sessions)

- Satcom Session–1: Satellite Communication Technology
- Satcom Session–2: Satellite Communication Application
- Satcom Session–3: Satellite Communication Commerce

- Satellite Navigation and Applications (2 sessions)
  - Satnav Session–1: Satellite-based Positioning, Navigation and Timing
  - Satnav Session–2: Satellite Navigation Business

- Space Science (3 sessions)
  - Space Science Session–1: Astronomy
  - Space Science Session–2: Planetary Science
  - Space Science Session–3: Solar and Terrestrial Science

- Space Education and Training (as a Plenary)

- Space Commerce (as a Plenary)

- Opening Plenary on India-U.S. Space Cooperation and Commerce: Status and Prospects

- Closing Plenary on Future Direction of India-U.S. Cooperation and Commerce

The broad programme outline of the sessions is given in **Annex I.**

## PARTICIPATION

The conference brought together 550 delegates – out of which about 150 were from US. It was for the first time that ~150 US professionals were directly exposed to Indian space capabilities – especially the interfaces of the programme between ISRO, government agencies, private sector, non-governmental organisations and universities in India. A total of 144 papers have benn presented in the conference. The Indian delegates obtained a first-hand information on the advanced technologies for space from the US presentations. A space Exhibition was also organized where about 16 US and 21 Indian agencies showcased their space technologies, products and services.

## OUTCOME

The outcome of the India-United States Conference on Space Science, Applications and Commerce is a set of recommendations for future bilateral civil space cooperation and commerce between the two countries. These recommendations were identified in the Conference through discussion of the state of the art in space technology and applications, and hold the potential for both nations to benefit from each other's capabilities and requirements. The recommendations can serve as a starting point for renewed bilateral engagement in civil space cooperation between India and the United States. The conference resulted in:

- A Vision Statement for future cooperative space activities between India and the United States.
- Technical reports of the sessions and discussions resulting in identification of detailed recommendations and potential areas to enhance cooperation and commerce between the two countries in the area of space.

While the Vision Statement is meant to suggest the overall direction that cooperation could take, the session reports identify important issues and specific actions as well as promising projects of a cooperative, technical and business nature for consideration of U.S. and Indian space scientists, engineers, industry leaders and policy-makers.

# INDIA - US SPACE CONFERENCE PROGRAMME

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<tr><td rowspan="2">Day – 3<br>(June 24, 2004)</td><td colspan="3">• SATCOM -PLENARY<br>• EO- PLENARY</td><td rowspan="2">• SPACE COMMERCE PLENARY</td><td rowspan="2">• SPACE EDUCATION & TRAINING - PLENARY</td><td>• PUBLIC OUTREACH -3</td><td rowspan="2"></td></tr>
<tr><td>• SPACE SCIENCE- PLENARY</td><td colspan="2">• SATNAV- PLENARY</td><td>• TIME FOR NETWORKING</td></tr>
<tr><td>Day – 4<br>(June 25, 2004)</td><td colspan="3">TECHNICAL VISITS TO ISRO CENTERS (CO-CHAIRS/RAPPORTEURS PREPARE REPORTS/RECOMMENDATIONS)<br>TIME FOR SIDE MEETINGS</td><td>• CLOSING PLENARY: FUTURE DIRECTION OF INDIA-U.S. COOPERATION AND COMMERCE</td><td colspan="2">• ADOPTION OF VISION STATEMENT<br>• VALEDICTORY SESSION (UPTO 1800 HRS)</td><td></td></tr>
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**Common Sessions** **Parallel Sessions**

# PROGRAMME SUMMARY

## VENUE: HOTEL GRAND ASHOK

**(ALL EVENTS IN HOTEL GRAND ASHOK UNLESS SPECIFIED OTHERWISE)**

### SUNDAY: JUNE 20, 2004

| | |
|---|---|
| 1400–1830 | MEETING OF PROGRAMME COMMITTEE WITH CO-CHAIRS OF SYMPOSIA/SESSIONS (CONVENTION HALL) |
| 1900 Onwards | DINNER FOR PROGRAMME COMMITTEE AND CO-CHAIRS (HOTEL GRAND ASHOK) |

### MONDAY: JUNE 21, 2004

| | |
|---|---|
| 0900–1430 | REGISTRATION FOR THE CONFERENCE (HOTEL GRAND ASHOK) |
| 1600–1830 | CONFERENCE INAUGURATION (JN TATA AUDITORIUM) |
| 1930 Onwards | OPENING RECEPTION AND DINNER HOSTED BY CHAIRMAN, ISRO (HOTEL LEELA) |

### TUESDAY: JUNE 22, 2004

| | |
|---|---|
| 0900–1230 | OPENING PLENARY: INDIA-US SPACE COOPERATION AND COMMERCE: STATUS AND PROSPECTS (BANQUET HALL) |
| 1330–1800 | EO SYMPOSIUM LEAD TALKS AND EO-1: EARTH OBSERVATION SCIENCE, TECHNOLOGY AND APPLICATIONS — NATURAL RESOURCES, WATER CYCLE AND INFRASTRUCTURE (BANQUET HALL) |
| | SATCOM-1: SATELLITE COMMUNICATION TECHNOLOGY (CONVENTION HALL) |
| 1330–1530 | SPACE SCIENCE-1 — ASTRONOMY (CHANAKYA HALL) |
| 1600–1800 | SPACE SCIENCE-2 — PLANETARY SCIENCE (SUITE 600) |
| 1800–1900 | PUBLIC OUTREACH-1 (BANQUET HALL) |
| | TIME FOR NETWORKING |
| 1930 Onwards | RECEPTION HOSTED BY U.S. CORPORATE SPONSORS (HOTEL WINDOSR MANOR) |

# PROGRAMME SUMMARY

## VENUE: HOTEL GRAND ASHOK

**WEDNESDAY: JUNE 23, 2004**

| | |
|---|---|
| 0900–1230 | EO-2: EARTH OBSERVATION SCIENCE, TECHNOLOGY AND APPLICATIONS — METEOROLOGY AND OCEAN SCIENCES (BANQUET HALL) |
| | SATCOM-2: SATELLITE COMMUNICATION APPLICATIONS (CONVENTION HALL) |
| | SATNAV-1: SATELLITE-BASED POSITIONING, NAVIGATION AND TIMING (CHANAKYA HALL) |
| | NATURAL HAZARDS RESEARCH & DISASTER MANAGEMENT SUPPORT (SUITE 600) |
| 1330–1530 | SPACE COMMERCE PLENARY-1: CHALLENGES AND OPPORTUNITIES FOR EXPANDED SPACE COMMERCE AND BUSINESS (BANQUET HALL) |
| | SPACE SCIENCE-3: SOLAR TERRESTRIAL SCIENCE (CHANAKYA HALL) |
| 1600–1830 | EO-3: EARTH OBSERVATION SCIENCE, TECHNOLOGY AND APPLICATIONS — ATMOSPHERIC COMPOSITION, SOLAR RADIATION & SUN CLIMATE (CHANAKYA HALL) |
| | EO-4: EO COMMERCE (BANQUET HALL) |
| | SATCOM-3: SATELLITE COMMUNICATION COMMERCE (CONVENTION HALL) |
| | SATNAV-2: SATELLITE NAVIGATION BUSINESS (SUITE 600) |
| 1830–1930 | PUBLIC OUTREACH-3 |
| 1930 Onwards | COCKTAILS AND DINNER (HOSTED BY JB BODA INSURANCE BROKERS, INDIA and NEW INDIA ASSURANCE) |

**THURSDAY: JUNE 24, 2004**

| | |
|---|---|
| 0930–1300 | EARTH OBSERVATION PLENARY (BANQUET HALL) |
| | SATELLITE COMMUNICATION PLENARY (CONVENTION HALL) |

# PROGRAMME SUMMARY

## VENUE: HOTEL GRAND ASHOK

**THURSDAY: JUNE 24, 2004**

| | |
|---|---|
| 0930–1100 | SPACE SCIENCE PLENARY (CHANAKYA HALL) |
| 1130–1300 | SATELLITE NAVIGATION PLENARY (CHANAKYA HALL) |
| 1400–1530 | SPACE COMMERCE PLENARY-2: CHALLENGES AND OPPORTUNITIES FOR EXPANDED SPACE COMMERCE AND BUSINESS (BANQUET HALL) |
| 1600–1730 | SPACE EDUCATION AND TRAINING PLENARY (BANQUET HALL) |
| 1730–1830 | PUBLIC OUTREACH-2 (BANQUET HALL) |
| | TIME FOR NETWORKING |

**FRIDAY: JUNE 25, 2004**

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|---|---|
| 0930–1300 | TECHNICAL VISITS TO ISRO CENTERS |
| | CO-CHAIRS/RAPPORTEURS PREPARE REPORTS/ RECOMMENDATIONS (BANQUET HALL) |
| | TIME FOR SIDE MEETINGS |
| 1400–1530 | CLOSING PLENARY: FUTURE DIRECTION OF INDIA-U.S. COOPERATION AND COMMERCE (BANQUET HALL) |
| 1600–1800 | ADOPTION OF VISION STATEMENT (BANQUET HALL) |
| | VALEDICTORY SESSION (BANQUET HALL) |

# INAUGURAL SESSION AND OPENING PLENARY

# INAUGURAL SESSION

The Inaugural Session of the Conference was organized on June 21, 2004 at the JN Tata Auditorium, Indian Institute of Science Campus, Bangalore.

The Conference was inaugurated in a ceremonial manner by Mr. Prithviraj D. Chavan, Minister of State for Prime Minister's Office, Government of India. Mr. Chavan delivered the message of the Prime Minister of India in his inaugural address. Dr. David C. Mulford, Ambassador of the United States of America to India delivered the message of the President of the United States and also addressed the gathering. In the inaugural function, Mr. Madhavan Nair, Chairman of ISRO and President of ASI, and Mr. Kenneth I. Juster, U.S. Under Secretary of Commerce, addressed the gathering. Dr. Frederick Gregory, Deputy Administrator of NASA and Gen. John J. Kelly, U.S. Deputy Under Secretary of NOAA delivered the message of the administrators of NASA and NOAA. Earlier, Dr. P.S. Goel, Director of ISAC and Chair of the Indian National Advisory Committee for the Conference, welcomed the dignitaries and delegates to the Conference. Finally, Mr. S.K. Das, Additional Secretary, Indian Department of State, proposed a vote of thanks.

Dr. Goel welcomed the dignitaries, who were honoured with floral bouquets. He mentioned that the spirit of togetherness and commonality of goals of the two nations has been the motivator for the conference. He gave a brief overview of the Conference and its sessions and hoped that the event would pave way for many more steps and activities to be taken up between the two countries.

Mr. Chavan, in his inaugural address, quoted from the message of the Prime Minister of India — who struck a note of optimism and recognized "that there is vast scope for bilateral high-technology commerce — including civilian space commerce. Strong economic ties in high technology based on mutual trust can greatly supplement our shared values and political interests in providing an enduring foundation for a strategic partnership. While our two governments are taking steps to create the appropriate environment for successful high technology commerce, this Conference would help in identifying and generating an awareness of market opportunities. It can also contribute to building additional confidence between the two countries for such cooperation, in a way that reflects their transforming relationship and common interests." Mr. Chavan highlighted the significant achievements of the Indian space programme. He noted that the technological capabilities in space in India and the United States could be the basis for a joint capability that can leverage many advantages to the benefit of both nations. He mentioned that the world is enthused by the new vision of space that has been unveiled by President Bush and hoped that the space agencies of the two nations can collaborate in the future missions and bring about a synergistic harmony to the research and technological growth in both space programmes.

Dr. Mulford delivered the message of the President of the United States and mentioned that "India and the United States share a history of more than four decades of cooperation in space. Our risk-takers and visionaries have expanded human knowledge, revolutionized understanding of the universe, and produced technological advances that have benefited all of humanity. This conference gives participants an opportunity to identify new opportunities for civil space cooperation to answer scientific questions, improve the quality of life for others, and inspire the next generation to explore our universe." In his address, Dr. Mulford called for "giving each other space" and mentioned that international cooperation in space can help build stronger relations between countries, contribute to economic and social development, and expand the frontiers of human knowledge. In the United States alone, more than 1,300 different space technologies have helped save lives, contributed to U.S. industry, and improved the quality of life for the common person. India is pioneering the use of space technology for development through telemedicine and tele-education. Drawing on

the advice and experience of government policy-makers, leaders in aerospace commerce and researchers in space science and technology from our two countries, Dr. Mulford was confident the Conference would lay the foundation for continued commercial, development and research opportunities within the growing bilateral relationship.

During his address, Mr. Nair gave an overview on the applications-oriented space programme of India and stressed that Indian space was oriented towards societal and national development. He mentioned that both United States and India have a successful history of space activities and their own strengths and noted that there have also been many instances of successful co-operation. With this background auguring well for exploring future cooperative and collaborative ventures for mutual benefits, Mr. Nair called for exploiting such opportunities and the need to move forward with a focused vision, concrete strategy and determination to tackle the challenges ahead. He noted that that this conference would be a major step in this process**.**

Mr. Juster expressed enthusiasm at the possible opportunities in high-technology commerce between India and the United States and noted that civilian space promised tremendous potential for cooperation between the two nations. Emphasizing that there were no sanctions against any space agencies/entities of India and only licensing requirements, Mr. Juster mentioned that the United States looked forward to increasing legitimate trade and business opportunities with all nations, including India.

During his comments, Dr. Gregory described his experiences as an astronaut, especially the view of Earth and how he viewed India from space. He shared his belief in the need for unity in the world, since we all live on the same planet. He also complimented space technology developments in India and noted the close links ISRO had with NASA. He presented the U.S. President's New Vision of Space, which envisioned mankind's quest for knowledge by reaching out to the Moon, Mars and beyond. He mentioned that the unlimited possibilities in space for benefiting mankind are prompting NASA to set future goals and that international cooperation was an important element of that.

Gen. Kelly presented the NOAA perspective of space applications and mentioned that Earth observation is the core of NOAA's activities. He noted that the United States and India faced common problems of disaster management, which called for a strategy of using the right tools in managing disasters. He highlighted the role of EO in addressing meteorological and oceanographic datasets, which are crucial for a number of applications. He mentioned that the United States supported the establishment of the Global Earth Observation System of Systems (GEOSS) and hoped that India and the US could work together in the area of EO.

Mr. Das, in his characteristic friendly style that the delegates appreciated and applauded, proposed a vote of thanks and expressed gratitude and thanks to the two governments, the dignitaries on the dais, the delegates and everyone associated with the conduct of the Conference.

# OPENING PLENARY: INDIA-U.S. SPACE COOPERATION AND COMMERCE: STATUS AND PROSPECTS

Co-chairs:

G. Madhavan Nair, Chairman, ISRO, India
V. S. Ramamurthy, Secretary, DST, India
Kenneth I. Juster, Under Secretary of Commerce, USA
Frederick D. Gregory, Deputy Administrator, NASA, USA
John J. Kelly, Deputy Under Secretary, NOAA, USA
Lee M. Morin, Deputy Assistant Secretary of State, USA

Rapporteur:

V. Sundararamaiah, Scientific Secretary, ISRO

## PLENARY SUMMARY

Mr. G. Madhavan Nair gave a comprehensive presentation on the space programme of India and highlighted its societal and national development orientation. The Indian space has evolved over a period of 40 years into a programme that includes operational space-based communications, earth observation for natural resources management and indigenous capability to launch satellites into polar and geosynchronous orbits. Mr. Nair highlighted some of the national applications being done in India using space — specifically tele-medicine, tele-education, broadcasting, remote connectivity, business networks in the field of space communications; targeting ground water crop acreage estimation; mapping natural resources; disaster management support, using Indian remote sensing satellite system; astronomy and planetary science as part of the space science programme and the capabilities of Polar Satellite Launch Vehicle (PSLV) and Geo-synchronous Satellite Launch Vehicle (GSLV). The future missions of ISRO include the forthcoming Edusat, Cartosat and Chandrayaan missions.

Mr. Nair highlighted the past cooperation between India and the United States — specifically in the initial periods of sounding rockets launch, Satellite Instructional Television Experiment (SITE), Landsat data acquisition, INSAT procurement from United States and other important events. He stressed the need for building the foundation for a next generation partnership that would encompass the areas of sharing EO data and modeling applications, planetary explorations — specifically to the Moon, training and education and also the high potential for industries of both nations to partner. International cooperation is an important element of India's space endeavors and India looked forward in enhancing cooperation with the United States to higher levels. Mr. Nair stressed the fact that India has a large pool of talented and knowledge manpower, which could be leveraged for the benefit of the world in the activities of space, as has been done in other areas. The outcome of a road map from the conference could enable both nations to take concrete steps for enhanced cooperation and mutually benefiting commercial partnerships.

During his comments, Mr. Kenneth Juster explained that in the last three years the United States and India have reinforced the foundation for sustained joint efforts in civilian space activities and noted that the challenge is to lay out concrete ways to move forward in space cooperation based on the common goals of a more peaceful and prosperous world. He underscored the importance of joint efforts — together we can achieve much more than we

can individually — and emphasized that both nations have seen a dramatic acceleration of progress made possible by harnessing the potential of space. Even at this time of accelerated technical and social progress, there is also a period of great peril when disaffected groups in the world seek to halt mankind's advance to ever-greater peace, prosperity, and freedom. We must recognize that our progress forward hinges, in substantial part, on our ability to develop, improve, and use space technology for peaceful purposes.

Mr. Juster cited statistics of high-technology trade between India and the United States and mentioned that the United States had approved 90% of all dual-use licensing applications for India, with the value of such approvals more than doubling to $57 million (from $27 million in 2002) and the value of license applications that were returned without action dropping dramatically from over $535 million (in 2002) to approximately $35 million in 2003, thus indicating that exporters were getting the word that sanctions had been lifted. He said that the same trends are occurring with regard to U.S. licensing decisions for sophisticated exports to ISRO. For the last year and a half, the number of licensing decisions for ISRO and its subsidiaries has increased by 75%, with the approval rate now running at approximately 93%. These are very positive and very noteworthy trends.

Mr. Juster announced the clearance by the U.S. government of Boeing's technical assistance agreement to engage in discussions and share data with ISRO on the division of responsibility for possible joint cooperation in the development and marketing of communications satellites. Stressing the fact that there were no sanctions against ISRO, he noted that the United States would like to advance cooperation in high-technology trade, civilian space activities, and other areas in ways that do not undermine the general international framework on non-proliferation. He concluded by noting that together, the United States and India have the potential to transform the future into a safer, more prosperous tomorrow so that both nations can harness civil space cooperation for the lasting benefit of all humankind. Mr. Juster concluded that the seeds of that cooperative effort have already been planted and the mission at this Conference is to nurture their growth.

Mr Sheelkant Sharma gave a perspective of the Indo-U.S. relationship and the steady progress made by both sides after the announcement of the Next Steps in Strategic Partnership. He noted that the Government of India laid special emphasis on the development of science and technology and successive governments, including the present one, whole-heartedly support science activities in India. Specifically, space is seen as important because of its mission-oriented success approach that has brought laurels to the country as a symbol of indigenous development of high technology. The United States shares this strong emphasis on science and knowledge, and thus science and technology becomes a natural area for cooperation between the two nations. Sharma recalled the past collaboration between the two nations in the area of space and also some of the recent developments in bilateral cooperation for furthering the high-technology commerce and trade. He reiterated the fact that Indian space activities were mainly for supporting the developmental activities in the nation and had indigenously evolved through a process of technology development, experimentation to operationalization. He also stressed the fact what India was doing in a very peaceful manner was not inimical to the interest of any nation. Welcoming the statements of Under Secretary Juster about there being no sanctions against ISRO and also about the increasing licenses for high-technology trade, Sharma stated that political perspectives must bring about the necessary conducive environment and atmosphere which will nurture and also grow the bilateral activities in this high-technology area.

Dr. Fred Gregory described his experiences as an astronaut and also detailed the view of Earth from space. Space posed a challenge for humankind with its open and vast realms,

providing the most appropriate environment for material processing, manufacturing medicines, understanding the Earth and reaching out to the vast universe. He acknowledged the contributions of many Indians — specifically Dr. S. Chandrasekhar, the Nobel Laureate, in whose honor the most powerful NASA space observatory was named. He also outlined the vision for space exploration recently announced by the U.S. President. The President called for advancing the scientific, security and economic interest of the United States through a robust space exploration programme by extending human presence across the solar system, starting with the return to the Moon and followed by human exploration of Mars and other destinations. Gregory concluded that international cooperation was an important element of this vision and welcomed participation by other nations. Thus, Indian and U.S. scientists could join together in making this vision of humanity a reality.

Dr. Lee Morin mentioned that the United States and India are justifiably proud of their national space programs and spoke about the impressive accomplishments of NASA and ISRO over the years — specifically in remote sensing, space communications, space launch, telemedicine and other areas where the United States and India are among a small, elite group of nations with state-of-the-art capabilities. He noted that both countries have a strong commitment to using space for peaceful purposes, not just for the benefit of their own citizens but for the benefit of all humankind. Both countries have a growing interest in commercializing their national space activities. He identified a number of areas with great potential for enhanced cooperation between American and Indian experts. Among those areas are: spatial data infrastructure, where India and the United States have tremendous capability; sharing remote sensing data and efforts to promote the Global Earth Observation System of Systems; space science; navigation, where a consultative mechanism between India and the United States could promote cooperation in the use of GPS, other satellite navigation systems such as Europe's planned Galileo system, and augmentation systems such as India's planned GAGAN system; and collaboration in planetary missions. With such a wide canvas of possibilities, Morin stated that he hoped the Conference would identify key areas of opportunity. As the two countries move forward on their agreed plan to expand cooperation in civilian nuclear activities, civilian space programs, and high technology trade under the Next Steps in Strategic Partnership, he was optimistic that industry-to-industry ties will flourish.

Gen. John Kelly explained that the United States and India are involved in the ongoing international effort to develop an integrated and sustained Global Earth Observation System of Systems (GEOSS), which can have far-reaching benefit for humankind. He mentioned that the United States and India are no strangers to the special challenges that arise from economic development and environmental protection and noted that urban centers will continue to grow and many of these centers are located in coastal regions — key areas on which we rely for healthy fisheries, commerce, and navigation.

Unfortunately, we will also witness increased potential vulnerability to natural disasters, particularly in floodplains and along the coasts. There will also be an increased demand for basic resources. Addressing these needs will require devising more efficient farming methods, improving weather and climate forecasting, and formulating plans for quickly responding to infectious disease outbreaks. Kelly stated that none of this will be made possible without improving our current limited understanding of the complex and interconnected systems of our planet through improved observation systems. He noted the stewardship role of the United States and India in CEOS and the recent EO Summit. He mentioned that the two nations must continue leading the larger international effort to establish a comprehensive GEOSS through a major initiative involving government agencies and institutions, industry and academia, and civil society.

## KEY OBSERVATIONS

Mr. V. Sundararamaiah wrapped up the session by providing a set of summary observations:

- Unanimous acknowledgement by all speakers of the high potential for cooperation and commerce in the area of space.
- Need to provide a conducive environment and policies that would encourage high levels of cooperation and commercial partnerships.
- Emphasis on the fact that there were no U.S. sanctions prevailing against ISRO.
- Observation on the increasing U.S. licenses and bilateral trade volume in the area of high-technology commerce, including space in the past 2–3 years.
- Several potential areas such as earth observation, space science, planetary missions, developmental applications, and industry partnerships were highlighted by speakers.
- Announcement of the clearance by the U.S. government of Boeing's technical assistance agreement for discussion and data sharing with ISRO on the division of responsibility for possible joint cooperation in the development and marketing of communications satellites.
- India's trained human resources capital could leverage benefits for both sides through effective partnership – specifically through industries.

# SYMPOSIA REPORTS

The following symposia reports represent the considered advice of participants in their personal capacities as experts and do not necessarily reflect the views or positions of individual governments, agencies, institutions or companies.

# EARTH OBSERVATIONS SYMPOSIUM

Co-Chairs:

Ghassem Asrar, Associate Administrador, NASA, USA
R R Navalgund, Director, NRSA, India
Gregory Withee, Associate Administrator, NOAA, USA

Rapporteur:

R Sudarshana, Head (PPEG), NRSA, India

# EO-1: EARTH OBSERVATION SCIENCE, TECHNOLOGY AND APPLICATIONS — NATURAL RESOURCES, WATER CYCLE AND INFRASTRUCTURE

Co-Chairs:
V Jayaraman, ISRO, India
Felix Kogan, NOAA, USA

Rapporteur:
Sanjay Srivastava, ISRO, India

## SESSION SUMMARY

Driven by the respective applications needs, Earth Observation (EO) has attracted different priorities in India and the United States. EO, in India, is used for the areas related to food security, poverty alleviation, ecological conservation and the development of social and physical infrastructure. EO has received wider support from user communities and, their requirements are translated into expanding the applications even at local level using GIS extensively. In the United States, EO products are focused mainly on climate and environment, drought, forest fire, agricultural production, biosphere functioning and understanding the Earth systems.

The development of radiative-transfer models enabling a variety of EO products, understanding land surface processes in terms of fluxes and forcing, and managing the natural resources in relation to extremes of the climate events, global change and anthropogenic pressure are some of the key areas for Indo-U.S. cooperation. Mutual sharing of the data, experience and expertise in the framework of the cooperative framework is recommended.

## KEY FINDINGS

- EO provides operational inputs valuable to food and water security, agriculture, hydrologic, biospheric and climate modeling related studies, drought, floods and forest fires, environment protection and infrastructure development, climate forcing and trends, infectious diseases and global warming.

- More research and developments are needed in detection and monitoring drought/flood, crop and pasture production assessment in mixed crop and small land holding scenario, identification of suitable sites for the potential outbreak of mosquito-borne epidemics, assessment of fire risk, evaluation of vegetation health, ENSO impact on ecosystems, monitoring the irrigated and dry land agro-ecosystems, and crop pests and diseases.

- Cooperation among the various agencies like EO technology, applications, value added service providers, agro-meteorological advisories and down-the-line users needs to be encouraged to develop end-to-end EO products.

- Calibration, validation and in-situ observations need to be appropriately integrated, while developing appropriate, user-friendly EO products.

## RECOMMENDATIONS

- Integration of EO products in the development of Decision Support Systems in the areas related to agriculture, drought/flood management, land and water resources management, infrastructure development and environment protection is a much-needed requirement.

- Newer applications that are identified to be pursued jointly include precision agriculture in a developing country scenario; predictions based on climate forcing and climate trends – including the early warning for agricultural drought; development of EO products by fusion/merging of data from different sensors and by appropriate algorithms based on the understanding of radiative transfer phenomena; studying land surface processes; quantifications of social, economic and environmental benefits/gains of EO applications.

- To start with, the short-term goals are envisaged in terms of sharing the data, information and algorithms particularly in the context of studying land surface processes. The long-term goals include developing the cooperative framework to purse the contemporary research areas, as identified under the recommendations 1 and 2; and also generation of operational EO products generation, which could be disseminated widely.

## CONCLUSION

A cooperative framework between India and the United States exclusively in the area of EO is necessary to pursue the above three recommendations.

An institutional interface involving ISRO/NRSA with other interested knowledge partners such as IARI/ICAR, MRD and NHAI from India, and NOAA/NESDIS; USDA, Agriculture Research Service; NASA Ames Research Centre; University of Maryland, Department of Geography; and University of Texas, Center for Space Research need to be developed.

# EO-2 SESSION: EARTH OBSERVATION SCIENCE, TECHNOLOGY & APPLICATIONS — METEOROLOGY AND OCEAN SCIENCES

Co-Chairs:
M.S. Narayanan, SAC, India
R.C. Bhatia, IMD, India
Shobha Kondragunta, NOAA, USA

Rapporteur:
T. Srinivasa Kumar, INCOIS, India

## SESSION SUMMARY

This session had eight oral presentations and eight poster presentations from Indian and U.S. scientists addressing various aspects of satellite meteorology and satellite oceanography. Areas covered included Indian and U.S. sensors/satellites (planned/future), algorithms for parameter retrieval, data and data products, data exchange, data assimilation and modeling.

Meteorology and oceanography studies, being essentially of a global nature, require international collaborative efforts as well as data exchange. Variational method of data assimilation of raw radiances is one of the emerging areas that has potential for improving weather prediction. The session identified assimilation of data into ocean and atmosphere models as the key to various applications including scientific studies as well as operational applications. Improved retrieval of geo-physical parameters from current and future operational and research satellites using radiative transfer approaches is needed. Also, the validation of retrieved parameters in various climate regimes is required.

### KEY FINDINGS

- The meeting noted that the projects identified during the earlier two workshops of 1998 and 2002 were not followed up to the desired extent. Although scientist-to-scientist exchange had taken place in a few cases, progress could not be achieved basically for want of exchange of data.

- The immediate future satellite launches from India such as INSAT 3D (Imager and Sounder), Oceansat-II (Scatterometer and OCM), Megha Tropiques (MADRAS, ScaRab and SAPHIR) as well as other global programmes are the central issues on which collaboration is required.

- Data assimilation both in atmospheric and ocean models was identified as a key area to be pursued jointly.

- Calibration and validation of data from various satellite platforms was another area for potential collaboration

- Collaboration is required in areas relating to sensor development and launch and bus support.

## RECOMMENDATIONS

The recommendations are subdivided into two categories based on their importance.

## Category-1

- Retrieval of temperature, humidity profiles (INSAT 3-D), rainfall from microwave sensors, etc. (medium term)
- Assimilation of satellite radiances/parameters in regional / GCM for applications (medium term):
  - Cyclone track prediction
  - Coastal and extreme event ocean state forecasts
- Validation and inter-calibration of data from sensors operating from various platforms collecting data over a specific parameter and region (medium term)
- Scatterometer model function development for Oceansat II Scatterometer on the lines of Quikscat (short term)
- Primary production modeling and fish stock assessment (medium term)
- Free exchange of all meteorological and ocean satellite and in-situ data, removing all impediments (short term)

## Category-2

- Merged products development and validation procedures (medium term):
  - Rainfall from geo infrared and polar microwave data
  - Sea surface temperature from infrared and microwave data
- Studying the possibility of including CHASM payload in Megha Tropiques Mission (medium term)
- Using GRACE data in ocean models (medium term)
- Aerosol studies from INSAT-3A (medium term)
- Collaboration between Indian Meteorological Society and American Meteorological Society (short term)
- The United States requests participation of working level scientists from India at international workshops
- Faculty for the UN CSSTE AP satellite meteorology course (short term)

# EO-3: EARTH OBSERVATION SCIENCE, TECHNOLOGY AND APPLICATIONS — ATMOSPHERIC COMPOSITION, SOLAR RADIATION AND SUN CLIMATE

Co-Chairs:
R. Sridharan, SPL, India
Don Anderson, NASA, USA
Sunanda Basu, Boston University, USA

Rapporteur:
C.B.S. Dutt, ISRO, India

## SESSION SUMMARY

There were seven presentations in total — three from India and four from the United States. The topics literally covered all the processes from very close to the surface of the Earth extending up to 1 AU, literally touching the sun!

From the Indian side the choice of the topics was made keeping in view of the strength of the Indian scientific community, the infrastructure developed over the years and the current topics of active research in atmospheric sciences. Topics were chosen that have global repercussions with a need for a global approach and hence provide ample opportunities for interaction, cooperation and collaboration between the Indian and U.S. scientists.

## NEED OF THE HOUR

- The different regions of the upper atmosphere such as troposphere, stratosphere, mesosphere, thermosphere/ionosphere, magnetosphere and also the high- and low-latitude regions are essentially coupled by dynamical, electro-dynamical and chemical processes that by themselves are geo-location dependent. Generation of different types of waves like, planetary waves and gravity waves and their characterization, are extremely important with respect to strato-tropo exchange, cloud characterization, monsoon dynamics, equatorial Ionospheric phenomena such as Equatorial Spread F. Concerted efforts have to be made through observational (both ground- and space-borne) and modeling to understand the complex interactive processes and be able to quantify and reach a level of predictability.

- The realization of the importance of aerosols in the radiation budget of the Earth and its possible impact on the Earth's Climate is rather recent and India has a vibrant program in this discipline. In spite of a significant increase in our knowledge, the uncertainties are still very large because of the complexities involved in the aerosol related processes. Aerosol chemistry is becoming an important element. Large-scale dynamical processes redistribute the aerosols from their source regions to rest of the globe, resulting in large spatial and temporal variability. Satellite measurements in conjunction with global ground-based observations of all the relevant parameters hold the key for the basic characterization, while one has to evolve realistic models for making an impact assessment. The satellite measurements depend on ground validation for realistic retrieval of the Aerosol properties.

- While the aerosols have an impact on the short-term variabilities, which could be called as the weather processes, the green house gases have the most significant impact on the climate. Altitude profiles of ozone, stratospheric-tropospheric exchange

estimates spatial mapping of the constituents that are relevant to atmospheric chemistry, through intensive road campaigns, using satellite platforms and also obtaining the altitude profiles with balloon platforms at different places are key to a realistic estimates. A concerted effort to assimilate the data and evolve a suitable model will be the prime concern of this branch of activity.

**RECOMMENDATIONS**

Concerted, coordinated attempts should be made to carry out systematic campaigns in addition to regular measurements of winds and temperatures, to delineate the variability and to quantify the role of long and short-period waves in terms of the energetic of the atmospheric regions. Extensive use of ground-based and satellite data (TIMED, GPS occultation techniques and the like) are called for in addition to the combination of satellite missions like C/NOFS and the ground-based facilities. There is enormous scope for modeling studies.

From the aerosols and trace gases point of view, blending the satellite date (MODIS, AQUA and the like), will be the top priority to quantify their relative roles with regard to radiation and eventually the climate. There is enough scope for mutual collaboration between India and the United States in carrying out extensive campaigns (mutual participation in the proposed campaigns by both the countries could be considered) on land, oceans and also using aircrafts. The ultimate aim would be formulation of a suitable model that could assimilate the large amount of data including the chemical composition.

**CONCLUSION**

It is recognized that there is strong overlapping interest in both the countries on science topics related to earth observation. It is strongly recommended that there should be interagency (ISRO-NASA) collaboration through joint scientific working groups to identify the scientific topics of interest and evolve the mechanism for speedy implementation. It is recommended that bi-lateral discussions focused on future collaboration between ISRO and NASA in programs such as Living With a Star. It is also recommended that inter-institutional programs facilitating free exchange of personnel from both sides on specific goal-oriented themes be encouraged.

# EO-4: EARTH OBSERVATION COMMERCE SESSION

Co-Chairs:
Mukund Rao, ISRO, India
Ashok R. Deshmukh, Technica Inc., USA

Rapporteur:
Rajeev Jaiswal, ISRO, India

## SESSION SUMMARY

The Earth Observation Commerce Session, as part of the EO Symposium of the Conference, was held on June 23, 2004 from 1600–1830 hrs. The session focused on the possible opportunities for business and commerce in the area of Earth Observation.

Both India and the United States have strong capabilities in Earth Observation — basically in designing and building state-of-the art imaging and non-imaging satellites. These capabilities are at the core of utilization in support of natural resources management, disaster management, GIS application, global change applications and earth system studies. As part of these capabilities, both nations have enabled a strong element of private sector involvement in the development, management, data distribution and applications in a wide variety of sectors. Key private sector companies of both nations participated in the session.

The session created lot of interest among the delegates and speakers debated and assessed the earth observation data capabilities in both nations and explored the possibility of identifying future business opportunities between interested parties. Eleven presentations were made in the session — mainly by leading personalities from the Indian and U.S. space industry.

The presentations focused on the private sector capabilities in this area and highlighted the following:

- Capabilities of various private sector industry of India and the United States
- IRS data distribution opportunities in United States and other nations of the world
- Opportunities for partnership between U.S. and Indian industries in global remote sensing and GIS
- Availability and potentials of U.S. commercial remote sensing data and utilization
- Capability of the United States for knowledge generation on the earth systems
- The high potential in both nations for remote sensing data value added services
- The importance of earth observation data sources from both nations to an integrated global information system
- EO data as an important source of input to GIS and decision support systems
- The business for spatial data infrastructures and developing commerce for enabling a national and a global spatial data infrastructure

## KEY FINDINGS

The presentations and subsequent discussions in the session highlighted the following key observations:

- Most industries from both sides expressed apprehension about policy and environments in both nations, which they felt needs to be more encouraging and motivating industries to partner.

- The Indian Remote Sensing data is a very major source of multi-resolution imaging data sets, which has high potential for use in the U.S. civilian applications and also for applications in the world. The data can become a major input to the U.S. civilian agencies — specifically in the light of non-availability of similar data from other sources.

- The Indian remote sensing applications and GIS industry is very vibrant and has tremendous capability to partner with similar industries in the United States to offer global value added services and solutions — specifically using the U.S. capabilities of high-resolution data integrated with the IRS data. There is a need for bringing opportunities for such partnerships to happen and also for positioning the right policies in the two nations for such technical arrangements. Such arrangements could leverage considerable commercial benefits to companies on both sides.

- The United States has advanced and high-technology capabilities in the private sector, which can be a major input for designing and developing, advanced remote sensing satellites. India has high level of system design capability for such advanced remote sensing satellites and can offer cost-effective solutions. The right environment needs to be created for enabling such partnerships and for the benefit of both nations.

- The Indian Remote Sensing capability could be leveraged to provide the solutions for the LANDSAT Data Continuity Mission (LDCM) –, which the United States is presently trying to configure for the coming years. With high potential for partnership by U.S. and Indian industry to offer to the U.S. government a joint solution for the LDCM, this initiative needs to be encouraged so that it can become the pride of Indian-U.S. cooperation in space.

- The Indian capabilities for the design development and management of Spatial Data Infrastructures (SDI) could be well integrated into U.S. federal programs of the NSDI. Technological solutions, software solutions and application services could be the core of a strong partnership between these initiatives, which could not only benefit both nations but also provide tremendous standardization and technological solutions for other countries to built and maintain their SDIs.

- Partnership between India and U.S. industry could lead to building and launching high resolution satellites which could provide data with better turn around time and reduced cost.

**RECOMMENDATIONS**

The following recommendations are made:

- The governments of both nations should create a favorable environment and conducive policies for technical and commercial arrangements between the industries of the United States and India for leveraging the respective technical and cost strengths of both nations in the field of EO satellite design, development, management, utilization, services and solutions, etc.

- As an immediate possibility of cooperation, the IRS-P6 offers an excellent opportunity. With the data gap for U.S. federal agencies — USDA, USGS, NGA, etc., and other private sector agencies in the United States, special arrangements could be made between India and US by which IRS-P6 data could become the core of geospatial intelligence and information for the United States.

- The U.S. civilian remote sensing industry have many high-resolution satellites in the orbit that can be a major input to the developmental activities in India – mainly in terms of generating large-scale spatial information. There is a need to generate integrated solutions of being able to fuse data from different sources for variety of applications. Many delegates expressed that the costs of the U.S. high-resolution datasets were quite prohibitive from Indian considerations.

- The Indian and U.S. industry should be encouraged to develop joint arrangements for a cost-effective solution to the U.S. government for the LDCM.

- The United States has high-technology solutions for advanced remote sensing and these could become accessible for the Indian remote sensing satellites — thus generating opportunities for high technology commerce.

- Indian GIS industries can become the back office processing centres or providing cost effective EO and GIS solutions to the U.S. industries, government and also for global requirements. The possibility of such joint initiatives must be encouraged.

- Integrate the private sectors of the United States and India that have the capability and desire to work together for a global information system.

- The U.S. and Indian governments should work together to integrate the high capability of SDI technologies and solutions available in their respective nations to leverage advantage not only to India and the United States but to be able to offer standardized solutions and services for a Global Spatial Data Infrastructure (GSDI).

# EO-5: NATURAL HAZARDS RESEARCH AND DISASTER MANAGEMENT SUPPORT

Co-Chairs:
K. V. Venkatachary, ISRO, India
Eva Zanzerkia, NASA, USA

Rapporteur:
B. Manikiam, ISRO, India

## SESSION SUMMARY

The session consisted of six technical presentations and a panel discussion. The invited talks were highly informative and led to exchange of current developments in use of space data for disaster management. The deliberations have led to identifying specific areas for collaborative work that include risk assessment, decision support tools development, improved forecast techniques and in-situ observation network. Developing a constellation of satellites/sensor web is another overarching recommendation. The mechanism of setting up a Joint Working Group with experts from India and the United States has been suggested to pursue the collaborative efforts.

## KEY FINDINGS

There were six scientific presentations relating to various aspects of disaster management including current applications of space data and the following specific points were highlighted:

- The national system in India envisages the operational use of emerging technologies such as remote sensing, GIS and satellite communication to meet the information needs in various phases of disaster management.
- ISRO has initiated a major programme towards providing support to disaster management, with the key elements — decision support centre, digital database creation, airborne SAR development, hazard zonation with close contour data derived from ALTM surveys and emergency communication system, with appropriate networking with national and state emergency operations centres.
- The study on the seismic setting of the Indian landmass using GPS data, gravity anomaly mapping by GRACE mission and historic data on earthquakes has revealed the potential possibility of occurrence of large earthquakes in northern region. Potential use of InSAR data for precise analysis of ground movements for earthquake monitoring was mentioned, as was the potential use of InSAR as a monitor of damage in urban areas for disaster response support.
- The constraints in the current system in terms of technology, operational and policy/regulations has been analysed and the critical role of space systems to fill the gaps assessed.
- Use of multiple satellite data such as TERRA, AQUA, RESOURCESAT, MODIS, QUICKSCAT etc. in monitoring floods and cyclone induced heavy rainfall and flooding across the globe with a network of gauge data was brought out.
- Under the Government of India — USAID collaborative project, capacity building in key areas of cyclone forecast, flood forecast, severe weather, drought and forecast communication is envisaged.

A panel discussion on areas for collaborative work followed with panelists including Dr. S.V. Singh, Dr. S. Ngheim, Dr. Mahajan, Mr. M.V. Krishna Rao, Dr. Roger Bilham and Prof. R.P. Singh. Several concrete suggestions emerged from the panel discussion.

**RECOMMENDATIONS**

The recommendations fall in three categories — short, medium and long term; the potential agencies for participation could be ISRO, NOAA, NASA and several research institutions in India and the United States.

**Short Term (1-2 years)**

- Joint workshop/expert meeting on flood management to arrive at specific collaborative projects using multi-satellite data, ground network and analysis techniques.
- Expansion of the working groups to include 1) research of other natural hazards such as earthquake, drought and cyclones, and 2) operational aspects of disaster management support systems, such as gaps in data, techniques and decision support systems.

**Medium Term (5 years)**

- Risk assessment — develop appropriate techniques/tools for assessing the risk for the hazard-prone areas.
- In-situ real-time observation network to support space systems and validation (use of GPS, DCP, automated rain/river gauges).
- Development of decision support tools for use in operational scenarios.
- Improvement of forecast models for cyclones, floods and possible predictors for earthquake.

  In these areas we would like to ensure the exchange of appropriate data from ground- and space-based instruments, as well as joint cooperative efforts on fine-tuning available models for tropical regions.

**Long Term (10 years)**

- Development of a constellation of satellites/sensor web for operational support to disaster monitoring, forecast and communication. Because disasters are very dynamic, capturing the events in their totality require appropriate spatial, spectral and temporal coverage across the globe.

**CONCLUSION**

The Session was lively in terms of informative presentations and focused discussions leading to several areas for collaborative work. A unanimous suggestion that has emerged is to constitute a Joint Working Group with experts from India and USA to pursue the cooperative efforts.

# EARTH OBSERVATIONS PLENARY

Co-Chairs:
R. R. Navalgund, Director, NRSA, India
Gregory Withee, Associate Administrator, NOAA, USA
Ghassem Asrar, Associate Administrator, NASA, USA (preparation)

Rapporteur:
R. Sudarshana, Head (PPEG), NRSA, India

The Earth Observation Symposium consisted of five sessions, each corresponding to an important aspect of EO priority. The four sessions and their constituent number of presentations were as follows.

- EO-1: Natural resources, Infrastructure and Water Cycle (9 papers, 4 posters)
- EO-2: Meteorology and Ocean Sciences (8 papers, 8 posters)
- EO-3: Atmospheric composition, solar radiation and sun climate (7 papers, 1 poster)
- EO-4: Commerce (11 papers)
- EO-5: Natural Hazard Research and Disaster Management Support (6 papers)

In all, 41 papers and 13 posters, totaling 54 presentations, were made in the EO Symposium. The presentations were preceded by two principal talks by the co-chairs. Dr. Navalgund presented a perspective on the Indian EO programme and applications while Dr. Withee spoke on the U.S. ocean and atmospheric observation programme.

The reports and recommendations of each of the four sessions are appended herewith. The overall summary directions of the symposium, emerging out of the session summaries, deliberations and discussions is as follows.

**AREAS FOR COOPERATION**

Five areas of cooperation are identified towards crystallizing the conference deliberations into a mutually useful collaboration, as follows:

1. Agriculture
   - Crop condition
   - Yield assessment
   - Precision farming
   - Watershed development
   - Water resources
   - Fishery environment

2. Weather Systems
   - Air-Sea interaction, winds and SST
   - Aerosols and radiation
   - Atmospheric coupling – vertical and lateral
   - Trace gases
   - Cloud hydrology
   - Ocean bio-physical processes

3. Disaster Mitigation
   - Drought and Flood monitoring
   - Drinking water access
   - Forest fire and smoke
   - Biodiversity conservation
   - Geo-exploration (free air gravity and hazards)
   - Decision support tools for disaster management

4. Rural Extension Programme
   - Education
   - Health, hygiene and diseases
   - Environment
   - Infrastructure

5. Commerce
   - Generation and dissemination of products — especially use of IRS-P6 data in US Federal agencies and use of US high-resolution images for development activities in India
   - Private sector collaboration in value-added services for total solutions — especially in EO and GIS applications and SDI technologies
   - Joint arrangements to provide solutions for LDCM
   - High-technology trade for providing EO solutions
   - Knowledge systems/information systems
   - Promotion of IRS data utilization in federal organizations

## DIRECTIONS OF SUGGESTED COOPERATION

While the detailed recommendations on each of the above spheres of cooperation can be sought in the annexed reports, it is pertinent at this juncture to suggest on the possible directions that may be pursued towards strengthening and expanding the collaboration.

- It is observed that the environmental concerns and problems that are faced by India and the United States are similar, especially in the fields of food and habitat security. Although there are no common borders between the two countries, the intents and initiatives with regard to man and environment are common and hence a strong collaboration must be forged ahead.
- It is also seen that there are a few existing instruments of cooperation, especially the existing MoU between ISRO-NASA-NOAA and the recommendations of December 2002 Calverton Workshop. These existing initiatives are to be synergized with the presently evolving framework of cooperation. Together with the existing and evolving initiatives, a strong foundation for joint progress can be laid.
- Strengthening 'scientist to scientist' contact and industry-to-industry contact are a vital process to the success of the joint efforts to create a new and unique regime of earth observation applications.
- In the process of evolving a collaborative framework, it would be prudent to include a wide variety of institutions from the government, academia, industry and professional societies like IMS and AMS.
- Evolving joint campaigns of special importance in cutting edge science areas, such as inter-sensor cal/val exercises, leveraging the combined strengths of designing remote sensing sensors of the hyperspectral and microwave nature, etc. will optimize the combined resources at our disposal.
- Strengthening the joint efforts toward supplementing our individual capacities in generating space inputs for disaster mitigation is an avowed area for cooperation.

Developing forecasting, risk evaluation of hazardous zones, efficient early warning systems and even looking into the possibilities of forging new sensors and systems for disaster mitigation are an important direction.

- Need for favorable environment and conducive policies for technical and commercial arrangements between the industries of the United States and India for leveraging strengths of both nations in the field of EO satellite design, development, management, utilization, services and solutions, etc
- Exploration of joint opportunities available under Global Earth Observation System of Systems (GEOSS).

## MECHANISM SUGGESTED

To generate a critical scope on all the above recommendations and to specifically assess and enable the possibilities of cooperation, as suggested in each of the EO session reports, a Joint Working Group on Earth Observation (EO-JWG), with U.S. and Indian EO experts, may be constituted.

As far as scientific projects are concerned, the Indo-U.S. Science and Technology Forum could support the joint scientific proposals for implementation and bring together scientists to pursue their possible projects.

# SATELLITE COMMUNICATIONS

Co-Chairs:

Dave Ryan, President, Boeing Satellite Systems, Inc., USA
K N Shankara, Director, SAC, ISRO, India

Rapporteur:

D John, DD (Satcom), ISRO, India

# SATCOM-1 SESSION: SATELLITE COMMUNICATIONS TECHNOLOGY

Co-Chairs:
V. R. Katti, ISAC, India
Jim Simpson, Boeing Satellite Systems, Inc., USA

Rapporteur:
R.K. Rajangam, ISRO, India

## SESSION SUMMARY

Seven papers were presented in the SATCOM-1 session — part of SATCOM Symposium of the Conference — touching various aspects of communication satellite technology inclusive of its evolution over the years in India and the United States. The first paper by Mr. R. K. Rajangam, an Overview of ISRO's Communication Satellite Architecture, presented versatile capabilities of the satellite platforms such as I-1K, I-2K and I-3K. It also lucidly presented that how these platforms were utilized for Indian operational communication satellites providing communication, broadcasting and meteorological services. Ready adaptability of these platforms for medium-scale communication satellite application makes them attractive candidates for joint ventures and has potentials for bringing down cost per transponder.

Mr. Jim Simpson presented the state of art capability of Boeing Satellite Systems in the area of communication satellite technology, addressing its history from early evolution of Boeing-376 bus to the latest mega bus Boeing-702. He addressed Boeing's capabilities and evolution of technology over the years encompassing practically all the disciplines of communication satellite technology inclusive of high-power TWTA and high-efficiency multi-junction solar cells developments of Spectrolab at Boeing.

The presentation on the advances in the Platform Electronics and Stabilization Techniques by Mr. N.K. Malik touched the state-of-the-art development at ISRO in the fields of power, TTC, AOCE, inertial systems and unified bi-propellant system. It also highlighted the advances made in the development of stationary plasma thrusters and Bus Management Unit (BMU), which will eventually manage and control the satellite platform and monitor its health. The paper also addressed the infrastructural facility available at ISRO for design, development, fabrication, assembly, integration, testing and environmental testing of the satellite and its subsystems.

Dr. S. B. Sharma addressed the developmental efforts at ISRO in the area of space-borne antennas and feeds both of reflector and phased array type. He emphasized on the maturity of the design capabilities and its infrastructure availability at ISRO through the performance compliance of INSATs. Realization of complex dual gridded reflector through ISRO's design efforts and fabrication technology at Composite Optics Inc. (COI) of the United States was highlighted as fruitful collaborative effort. Sharma's presentation also covered realization of number of ground system antennas meeting the stringent user terminal requirements.

Dr. K. P. M. Bhat of Space Systems/Loral presented evolution of satellite technology at Loral since the days of INSAT-1 and INTELSAT-5 through INTELSAT-7 through the latest INTELSAT-9 & TELSTAR-8 systems. The FS-1300 bus, which evolved as a high-power platform, is being continuously upgraded from 6 KW to 25 KW through innovative use of high efficiency solar cells and thermal control designs needing deployable radiator panels. The presentation touched upon a number of innovative ideas and their practical realization in their operational systems and efforts for cutting down the cost per transponder. In

conclusion, it was also indicated that active Indian space industry participation in provisioning value added services for cost-effective joint venture solutions is to be explored.

Dr. H. O. Gautam presented evolution of transponder technology at ISRO and efforts for realizing sophisticated state-of-the-art communication transponder in S, C, Ext-C and Ku-Band for the operational INSAT Satellites. Innovative development of dielectric resonant input filters, ka-band transponder components and regenerative communication payload transponder employing onboard processing was also highlighted. The paper emphasized on the participation of Indian industry, realization of hardware and scope for joint ventures.

Dr. P. S. Nair presented the engineering capabilities of ISRO in the mechanical systems area that included structural design and analysis, thermal control design, analysis and hardware fabrication capability as well as design capability for complex deployment mechanisms and their realization through elaborate fabrication processes and testing. It was emphasized that the design capability at ISRO could not only meet ISRO's requirements but also could provide value added services in this area for joint ventures and innovative technology development.

**KEY FINDINGS**

- ISRO has state-of-the-art capability for realization of medium-scale communication satellite platforms, which can be suitably employed for varied joint venture applications.
- Design, testing capabilities and infrastructure of ISRO employing the high tech fabrication processes of the United States could lead to highly cost-effective realization of space borne antenna systems.
- Collaborative efforts in the development of high-power advance communication transponders could lead to reduction in the cost of realization and could offer attractive solution to distance education, telemedicine, disaster management and rural development through mass media.
- Innovative high-power communication satellites of the United States that can cater to high volume traffic could be realized through low-cost value added services of ISRO for mutual benefit.
- Design, analysis capability and testing infrastructure at ISRO for mechanical systems and software design and development capability can be utilized by U.S. industries. Innovative software tools and equipments developed by U.S. industries will have good market in India.

## RECOMMENDATIONS

- There is extremely good scope for collaborative undertakings, joint ventures and one-to-one cooperation provisioning schemes between ISRO, India and U.S. agencies.
- ISRO, Boeing Space Systems and Space Systems/Loral at present appear best place for carrying out joint venture tasks.
- As a medium-term measure, many of the Indian and U.S. space industries could be roped in to form consortia for mutual benefits and for commercial ventures.

As a long-term measure, collaborative R&D efforts could be initiated in India netting in the academic institutions with ISRO as a nodal agency and similarly academic institutions/industries with NASA as a nodal agency.

# SATCOM-2 SESSION: SATELLITE COMMUNICATIONS APPLICATIONS

Co-Chairs:
H. P. Dikshit, IGNOU, India
A. R. Dasgupta, SAC, India
Charles Doarn, University of Cincinnati, USA

Rapporteurs:
K. Bandopadhyay and Madhulika Kaushik

## SESSION SUMMARY

Nine papers were presented in this session from both the U.S. and Indian side. Most of the papers focused on distance education and telemedicine applications. One paper was on ground technologies developed in India for different SATCOM applications. The presentation of these highlighted significant interest in both disciplines. At the same time, it was felt that a suitable mechanism for sharing of experiences was lacking. This could give rise to repetition of mistakes and unnecessary wasted effort. Some of the papers brought out the need for standardization in terms of systems, software and content to meet the needs of interoperability and the need for international acceptability. Accreditation and transfer of credit for distance learning courses was another area of attention. Issues of cultural and language differences must be recognized. Collaboration must result in a win-win situation for all involved agencies and countries. The variety of applications showed that sufficient progress has been made in experimentation and the time for pilot studies is past. The requirement is to develop a sustainable program with adequate funding and a well-developed business plan, which must be developed with a comprehensive, needs assessment.

In view of these findings, the key recommendation is to establish a Joint Working Group consisting of members from ISRO, NASA, academia and industry that would develop a concrete plan of action to address the many facets of collaboration in the two areas, telemedicine and distance education. The plans would be reviewed periodically and an annual report, highlighting the areas of success and failures, would be prepared. The committee would have to identify suitable funding mechanism and sources of funding.

In the longer term, the recommendation is to address innovative technologies for applications in bio-terrorism control, homeland security and long-duration human space exploration. Convergence of applications of earth observations and communications should also be explored in the areas of disease prediction and disaster management. Such collaborative activities will highlight the mutually beneficial collaboration between the United States and India.

## KEY FINDINGS

The Satellite Communications Applications session resulted in a number of findings. These include the following:

- There are a number of areas of collaboration in telemedicine and distance education. There is a lot of interest in developing partnerships building on each other's strengths.

- A lot of work has been done in telemedicine and distance education in both the United States and India. Opportunity exists to share knowledge and experience.
- The current infrastructure for exchange of information is limited.
- There is an interest and need for technical standards, medical standards, educational standards, common terms, and common language.
- Accreditation and transfer educational credit are necessary.
- Building a sustainable program requires a comprehensive and realistic business plan and realistic levels of funding.
- There must be training programs in the use of telemedicine tools and systems and distance education systems.
- Well-defined programs must be initiated only after comprehensive needs assessment and definition of requirements. These must also be verified.
- A roadmap must be developed on how to organize and achieve any program/project goals and objectives. Who will fund these? Who will manage these?
- Collaborative activities must be mutually beneficial and demonstrated added value.
- Collaborations must be done with a good (not adequate) understanding of cultural differences and language.
- There is a definite need to share content through the exchange of knowledge basis.
- A virtual campus model available 24/7 is an interesting and valuable approach.
- Though primary interest lies on telemedicine and distance education, there is need to collaborate in other societal applications like earth observation, disaster management, village information system etc.

## RECOMMENDATIONS

The following recommendations are considered achievable in the short term:

- Explore the creation of joint collaborations in telemedicine and distance education using satellite resources with sustainable business models. Such collaborations should be done in a phased roll out.
- An India/U.S. Joint Working Group (JWG) should be established to address telemedicine and distance education activities as well as other joint collaborations. The composition of JWG could be: ISRO, NASA, representatives from service and manufacturing industries of the United States and India. The JWG should meet twice a year with a structured program with deliverables, including annual report on activities and successes.
- Efforts must be undertaken as soon as possible to identify collaborations with specific funding requirements and most importantly sources of funding.
- Realizing the importance and value of communication assets used in telemedicine (tele-health and medical informatics) and distance education, a mechanism must be created for information exchange and mutually beneficial collaboration.
- Indian telemedicine lessons learned must be shared with the U.S. telemedicine community at the earliest possible date. This can be accomplished in many different ways.
- The use of telemedicine and distance education in humanitarian efforts such as those proposed in Afghanistan are endorsed and encouraged. Such projects are of tremendous value.

The following recommendations are considered achievable in the long term:

- Evaluation of innovative technologies in telemedicine, tele-surgery, distance education, biosensors, MEMS, etc. for use in control of bio-terrorism, homeland security, and long-duration space exploration.

- Utilize earth observation technologies in imaging to support global health initiatives in disease management and disease prediction linked through a telemedicine network.

## CONCLUSIONS

Telemedicine and distance education are highly visible applications of satellite communication assets. These two disciplines can serve as broad foundation for mutually beneficial collaborations. These findings and recommendations demonstrate a willingness to meet on common ground for the benefit of all mankind.

Each side agreed to have a point of contact for further work. For telemedicine the U.S. point of contact is Mr. Charles R. Doarn of the University of Cincinnati. The Indian side would be L.S. Sathyamurthy of the Antrix Corporation Limited. For distance education, the U.S contact is Dr. Sheila Ryan of the University of Nebraska. On the Indian side the individual would be B.S. Bhatia (tentative) of DECU-ISRO.

# SATCOM-3: SATELLITE COMMUNICATIONS COMMERCE

Co-Chairs:
A. Bhaskara Narayana, ISRO, India
Ken Betaharon, Intelsat, USA

Rapporteur:
D. John, ISRO, India

## SESSION SUMMARY

In this session six papers covering a wide variety of topics on VSATs, DTH, satellite manufacturing and satellite insurance aspects were presented by Indian speakers and INTELSAT and PANAMSAT, the two large U.S.-based satellite operators. They provided their views on satellite communications and satellite services. The papers are of high quality and generated wide range discussions.

The worldwide satellite industry, which includes satellite manufacturing, launch services, transponder-leasing services and ground system manufacturing, registered a growth of 6% in 2003. Revenue in 2002 was 86 billion US$ and revenue in 2003 was 91 billion US$. There is a general decline in satellite manufacture industry by about 9% and satellite launch services by 14%. The ground equipment manufacturing revenue remained steady at 22 billion US$. In this scenario the growth in the industry is mostly in service sector led by direct-to-home broadcasting. The major issues facing the industry are the glut in the capacity of transponders leading to a low transponder lease rates and high cost of insurance of the satellite and the launch services. In Indian scenario INSAT with 137 transponders in various frequency bands provides the necessary infrastructure for domestic satellite communications and is the largest domestic communications system in Southeast Asia region. The demands from traditional INSAT users like the DOT, which uses 31 transponders, have been steady and there is a gradual decline in the demand for broadcast services provided by Doordarshan due to digitization. This is offset however by more operators providing satellite broadcast service and migration of other broadcasters in to INSAT system. VSAT industry is expanding in its scope and reach and many critical applications like National Stock Exchange, ATMs depend on the VSAT technology. Many more services are using VSAT technology and new and emerging fields are applications of VSATs for telemedicine and Tele-Education. DTH service is being introduced in the country by three service providers and is expected to be operational by mid next years. The combining Internet service in the DTH platform will enhance the service and also will make it possible for Internet to reach more subscribers and will accelerate the process of development. To reduce the cost of satellite services there are urgent requirements to encourage local manufacturers of satellite ground equipment with the latest technology.

VSAT Application Growth and Opportunities in the Indian Scenario

Mr. Barathi of HCL Comnet India made a presentation on VSAT application growth and opportunities in Indian scenario. In India VSATs came into existence in 1980s for government use and in 1995 VSAT services were allowed to be used by private operators. There has been a steady and a healthy growth of 40% per year and there are total of 40,000 VSAT provided by seven service providers. There are several critical sectors utilizing VSATs such as PSBs, banks, stock exchange and stock markets, security and law enforcement authority. Innovations and improvements like revenue sharing, increasing the data rates, and reducing the antenna size were made to make the sector more attractive. These reforms should be carried forward to make the industry more competitive. Recent reduction in the

price of the ground equipment will encourage the industry to venture into new areas and applications like digital cinema, etc. Tele-health and Tele-education are two areas where tremendous potential exists to use VSAT technology and reduction in the cost of the bandwidth, less government regulations and emergence of open standards will make the service more effective. It must be recognized that the quality and the cost of the service will ultimately drive the market rather than the technology.

INTELSAT and Space Commerce in India — A Satellite Communication Services Perspective

Mr. Ram Manohar observed that INTELSAT is one of the top six satellite operators in the world with 29 satellites. INTELSAT had close working relation with VSNL; ISRO during last 40 years and India was one of the major shareholders in INTELSAT before its privatization. INTELSAT has leased nine transponders from INSAT-2E called APR-1 and similarly it has leased transponders from Republic of China and is a truly global operator. INTELSAT is also entering in to the service sector and sees an opportunity for providing broadband service in the Southeast Asian region. World over satellite manufacturers are going for smaller satellites to meet the demand the India's capacity to manufacture satellites along with the U.S. industry to be leveraged to become a global player. Also ISRO should work closely with administrations to remove the impairments in satellite regulation, which prevent early introduction of satellite services. India and U.S. satellite providers would work together taking advantage of India's expertise in satellite manufacturing and service in this region.

Satellite Role in DTH and Internet Services

Mr. K. Narayanan of Zee Telefilms has indicated that DTH service was introduced by Zee Tele films with a variety of 30 channels and likely to increase this to 100 odd channels in the near future. DTH provides access to education and entertainment to all the people living in India including remote and inaccessible areas. The user base is expected to expand to one million by mid 2005. If the Internet can be integrated in the DTH platform with return signal either by satellite or by terrestrial mean, it will enhance the use of DTH or also make Internet available to the remote and inaccessible areas spreading the knowledge base. The goal is to serve about six million subscribers with 50% of them with broadband connectivity. Technologies need to be developed to integrate DTH and Internet service in the same platform and the regulations should be modified to make such service feasible.

On Demand Services via Satellite

Mr. David Ball, vice president Asia-Pacific for Panamsat Corporation, gave an overview of satellite operations of Panamsat. He observed there is a large disparity in the transponder leasing rates in the various regions of the world. Because of the reasons of over supply the operators are selling the transponders below cost. Innovative services and service conditions should be developed to correct the situation. It was suggested to develop an IP-centric VSAT system permitting the establishment of communication networks, which can provide end user with tremendous flexibility in communication throughput and the usage pattern. These IP-centric VSAT systems have substantial technical advantage over legacy VSAT systems, which provide limited throughput from remote locations in periods of high utilization. The tariff regimes should be shifted from fixed costs to cost on use basis. Such a tariff system will encourage the use of VSATs and reduce their operation cost.

Satellite Communication Insurance and Underwriters' Perception on Space Insurance Related Risks

Mr. O. P. Rana of JB Boda Insurance Company presented on the issues of the satellite insurance market. As satellite insurance accounts for 20% of the cost of the satellite in

space, it becomes important in the arena of satellite commerce. Satellite insurance depends on the reliability of launch vehicles, track record of the satellite manufacturer and the health of the insurance industry.

Manufacturing Satellite Equipment – Challenges and Opportunities

Mr. Malav Mehta of Infinium India made the presentation. He observed that the Indian Telecom market ranks second largest market among the emerging economies. During 10th plan 1,750 billion Rs worth of investment is expected with 50 million fixed lines, 30 million cellular lines and 20 million Internet connections. India appears to be a promising market for deploying VSATs. The reduction in ground segment cost below 1000 US$ will push the market up in India. If assembly and integration are done in India this will become a reality. However, the change in technology and lack of standards could result in uncertain demand causing the risk factor. It is recommended to have partnership to produce the terminals in India at a competitive cost.

## RECOMMENDATIONS

- Optimally utilize the resources available in India and the United States to promote tele-education and telemedicine through satellite linkages. It will be necessary for the networks operating for these services to migrate to open standards to ensure interoperability.

- Indian and U.S. administrations should work in the ITU forums to reduce the regulatory restrictions to enable rapid deployment of satellite services.

- The strengths of ISRO to fabricate and launch small satellite should be exploited to serve the satellite industry.

- The satellite systems of the United States and ISRO should explore the possibility of providing the service in the Asia-Pacific region jointly.

- Development of IP-based service should be encouraged to reduce the bandwidth cost.

- Transfer of technology should encourage manufacturing of the satellite ground system in India, wherever necessary to reduce the overall cost.

# SATELLITE COMMUNICATIONS PLENARY

Co-Chairs:
Jim Simpson, Vice-President, Boeing Satellite Systems, Inc., USA
K. N. Shankara, Director, SAC, ISRO, India

Rapporteur:
D. John, DD (Satcom), ISRO, India

## EXECUTIVE SUMMARY

In the Satellite Communication Symposium, there was one plenary session and three separate sessions on technology, applications and commerce. The large number of papers presented and the discussions that followed showed that both India and the United States has well-developed infrastructure and industries and are already in this business of satellite communications. It was also evident that there is a lot of interest in sharing experiences and in the joint collaboration between the United States and India on satellite communications.

Reports of the three individual sessions on Technology, Applications and Commerce were presented in the plenary and discussions were held on the recommendations.

The reports of the individual sessions follow the plenary report.

## RECOMMENDATIONS

The Satcom Plenary endorsed the recommendations of the three sessions and recommended them to be taken up for implementation — as specific activities between the two nations.

# SATELLITE NAVIGATIONS SYMPOSIUM

Co-Chairs:

K Ramalingam, AAI, India
David Turner, Department of Commerce, USA

Rapporteur:

SV Kibe, Programme Director, Satnav, ISRO

# SATELLITE NAVIGATIONS SYMPOSIUM

## SATNAV-1: SATELLITE BASED POSITIONING AND TIMING

Co-Chairs:
Surendra Pal, ISAC, India
Michael E. Shaw, Department of Transportation, USA

Rapporteur:
L Mrityunjay, ISRO, India

## SATNAV-2: SATELLITE NAVIGATIONS BUSINESS

Co-Chairs:
SV Kibe, ISRO, India
Stephen G. Moran, Raytheon, USA

## SATELLITE NAVIGATIONS PLENARY

Co-Chairs:
K Ramalingam, AAI, India
David Turner, Department of Commerce, USA

Rapporteur:
S.V. Kibe, Programme Director, Satnav, ISRO

## SYMPOSIUM SUMMARY

Representatives from the United States and India from both government and industry participated in the Satellite Navigation Symposium on June 23-24, 2004 to discuss opportunities for business development through possible collaborative business ventures serving national and global markets, and to facilitate enhanced cooperation and encourage active networking among government agencies, private enterprises, and academic and research institutions to the benefit of both nations and the world.

Presentations and resulting discussions during the symposium focused on government policies and plans for providing satellite navigation systems, and on technology, applications, and business opportunities resulting from the use of satellite navigation. Specifically, the following topics were addressed:

- U.S. GPS policy, management, and international cooperation
- GPS and augmentation systems modernization
- Indian Space-based Augmentation System (SBAS) known as GAGAN, and interoperability and ionospheric research issues related to the deployment of GAGAN
- SBAS ground segment technology and business issues
- Institutional and legal issues related to the provision of satellite navigation
- GPS receiver development in India for navigation and timing applications
- High-precision GPS applications
- Application of satellite navigation to location-based services and markets

The United States is moving toward realizing the full potential of satellite navigation for users worldwide by modernizing GPS and its U.S.-government provided augmentations. This modernization is taking place through the interagency management of GPS and GPS augmentations and under the guidance of a policy to provide GPS-based civil service to users free of direct charges and in a manner that allows the free and open publication of all system and signal information necessary to develop receivers and related user equipment for an ever increasing variety of positioning, navigation, and timing applications.

India is also actively involved in the provision of satellite navigation services through the development of the Space-based Augmentation System known as GAGAN (GPS Aided Geo Augmented Navigation). ISRO, along with Airports Authority of India (AAI) is jointly managing the program to implement GAGAN for the Indian region to fill the gap between EGNOS (European GNSS Overlay System) and MSAS. Although primarily meant for civil aviation, GAGAN will also be beneficial for other users as well.

New markets for satellite navigation are being realized every day, ranging from public safety transportation applications to mainstream consumer applications such as location-based services. The continued growth of the satellite navigation system or systems in a compatible and interoperable manner will certainly benefit the United States and India, and all users worldwide.

## KEY FINDINGS

- **Finding 1** — Confusion seems to exist in India's user community regarding the commercial availability of high-precision dual-frequency GPS receivers.

  Questions were raised related to the availability of high precision GPS receivers utilizing proprietary techniques to track the L1 and L2 GPS carrier frequencies. Some participants were under the incorrect assumption that U.S. export control law was limiting the export of these receivers to organizations in India. Others speculated that Indian import rules were the cause of the perceived problem.

- **Finding 2** — India has teams of experts with demonstrated capabilities in GPS receiver manufacture and applications that should prove beneficial to future U.S.-India industrial partnership and should benefit consumers as the Indian market continues to grow.

- **Finding 3** — SBAS development and deployment depends on trust and collaboration between the developer and the customer.

  This trust and collaboration is challenged by the nature of space system development as a relatively high-risk endeavor, while aviation users are inherently risk averse.

- **Finding 4** — The U.S. government does not actively engage India in cooperative satellite navigation application programs and technologies outside the area of aviation.

- **Finding 5** — Many countries around the world are establishing differential GPS reference station networks to replace traditional monument-based control networks and to provide integrity monitoring and uniform error correction nationwide.

- **Finding 6** — Mobile location-based services are revolutionizing value added services and providing new revenue opportunities for cellular providers, offsetting decreasing revenues from wireless voice services.

  Revenues from Location-based Services (LBS) are projected to exceed $20 billion by 2005.

- **Finding 7** — A lack of accurate digital maps could limit the ability to implement location-based services in India and could limit the growth of the Indian market for these services.

- **Finding 8** — As in many other countries, including the United States, operation of unlicensed radio frequency devices can create interference with GPS/GNSS signals utilizing the radio navigation satellite service bands in India.

## KEY RECOMMENDATIONS

- **Recommendation 1** — The United States and India should pursue a joint statement on GPS and related satellite navigation systems cooperation that includes the goal of fostering an open trade regime for all civil satellite navigation goods and services not covered by International Traffic in Arms Regulations; and fosters the creation of working groups focused on civil satellite navigation applications and technology.

  The joint statement of cooperation in satellite navigation between Japan and the United States has resulted in productive collaboration focused on the interoperability of Japan's Quasi-Zenith Satellite System and GPS, in addition to their ongoing development of the fully interoperable multi-function transport satellite-based space augmentation system (MSAS). Ultimately a similar agreement with India may benefit both countries and lead to the growth of the domestic Indian market.

- **Recommendation 2** — The United States should make its export policies related to GPS receivers, transparent and readily available.

  This information could be provided on existing U.S. government-maintained web sites related to GPS, such as the U.S. Coast Guard's Navigation Center site (www.navcen.uscg.gov) and the Interagency GPS Executive Board's web site (www.igeb.gov).

- **Recommendation 3** — To improve the market environment in India for GPS high-precision receivers and related equipment, the U.S. government and industry should pursue a partnership with India and private industry to develop a dense differential reference station network useful for real-time kinematic (RTK) applications.

- **Recommendation 4** — U.S. government and industry should pursue cooperation in ionospheric research with India to help better understand ionospheric characteristics in equatorial regions

- **Recommendation 5** — U.S. industry should partner with Indian industry in areas of satellite navigation application where significant Indian expertise currently exists

- **Recommendation 6** — India should reduce import duties on satellite navigation goods and services to encourage growth in satellite navigation applications.

Although the short-term result could be reduced revenue for domestic industry, the long-term impact will be more rapid growth in application markets for satellite navigation goods and services as well as increased benefits to Indian satellite navigation users.

- **Recommendation 7** — India should focus on domestic LBS (location-based service) opportunities as a future market growth area.
  However, modifications to current policy and/or rules related to the availability of accurate maps may be necessary in order to make location-based services accurate enough to be marketable.

- **Recommendation 8** — India must be sensitive to the inherent susceptibility of satellite navigation signals to unlicensed in-band and out-of-band interference.

## CONCLUSIONS

The use of satellite navigation technology and the size of the global market for satellite navigation goods and services continue to grow, although not at an equal rate in all nations or regions of the world. This growth will certainly continue and increase in rate as existing satellite navigation systems and augmentations are modernized and new systems become operational, providing greater capabilities to users. However, international cooperation is critical to ensuring the global compatibility and interoperability of satellite navigation systems necessary for improved capability for applications from aircraft approach and landing to location-based services. Existing cooperation between the United States and India in the development of satellite-based aviation augmentation systems provides a foundation for the expanded cooperation necessary to ensure user benefits and commercial opportunities in numerous other additional application areas in both countries. The U.S. and Indian governments can continue a cooperative path together by immediately initiating discussions leading to a joint statement on the use and application of satellite navigation. Additional avenues to pursue the implementation of the recommendations provided include the existing Indo-U.S. Science and Technology Forum, and the relationship established between the American Institute of Aeronautics and Astronautics (AIAA) and the Astronautical Society of India (ASI) as a direct result of this conference.

# SPACE SCIENCES SYMPOSIUM

Co-Chairs:

George Joseph, Honorary Adviser, SAC, India
S C Chakravarty, Director, SSPO, ISRO, India
Sunanda Basu, Professor, Boston Univ., USA

Rapporteur:

Jayati Dutta, Scientist, ISRO, India

# SPACE SCIENCES SYMPOSIUM

## SPACE SCIENCE - 1: ASTRONOMY

Co-Chairs:
PC Agrawal, TIFR, India
Supriya Chakrabarti, Boston University, USA

Rapporteur:
G Srinivasan, RRI, India

## SPACE SCIENCE – 2: PLANETARY SCIENCE

Co-Chairs:
J N Goswami, PRL, India
Supriya Chakrabarti, Boston University, USA

Rapporteur:
G Parthasarathy, NGRI, India

## SPACE SCIENCE-3: SOLAR TERRESTRIAL SCIENCE

Co-Chairs:
R Sridharan, SPL, VSSC, India
Co-Chair: Sunanda Basu, Boston University, USA

Rapporteur:
C V Devasia, SPL, India

## SPACE SCIENCES PLENARY

Co-Chairs:
George Joseph, SAC, India
S C Chakravarty, ISRO, India
Sunanda Basu, Boston Univ., USA

Rapporteur:
Jayati Dutta, ISRO, India

## SYMPOSIUM SUMMARY

The space science program consisted of three sessions (a) Astronomy, (b) Planetary Sciences and (c) Solar–Terrestrial Science. Presentations were made in these sessions covering aspects of ongoing and future research indicating possible areas of cooperation.

- **Astronomy:** The astronomy session included four presentations in the areas of X-ray astronomy and infrared astronomy. Current and future research programs with space platforms were summarized. These included highlights of the Indian

astronomy mission, ASTROSAT, present and future U.S. missions in X-ray astronomy, Indian one meter balloon-borne IR telescope as well as ongoing IR Astronomy research program including Spitzer observatory for far-infrared studies. Also included were a brief presentation on GMRT science capability and several poster papers covering optical, infrared, ultraviolet, XUV and soft X-ray astronomy.

- **Planetary Science:** A comprehensive review on the status of planetary science research in India that highlighted the collaboration between Indian and U.S. scientists, particularly in the field of laboratory studies of planetary materials was presented. Current understanding of the Titan's upper atmosphere and the unresolved issues that will be addressed by the Cassini/Huygens mission was presented. A brief summary of the Indian mission to the Moon, Chandrayaan-1 was presented bringing out the complementary nature of the Indian moon mission and the proposed Lunar Reconnaisance Orbiter mission to the Moon by NASA in 2008. Results on crustal magnetic fields on Moon and Mars obtained from data gathered by the Lunar Prospector and Mars Global Surveyor missions were discussed emphasizing essential features of the magnetic fields on these planets. The prime reasons for going back to the Moon again and the need for both manned and robotic missions for planetary exploration were presented. Papers presented in the poster session dealt with (i) evidence of fullerenes in a K/T site in India (ii) identification of the precursor materials of the planet Mars, (iii) a sensitive detector for detection of ambient water molecules in the lunar atmosphere.

- **Solar Terrestrial Science:** The following presentations were made: (a) the outstanding problems of low-latitude ionospheric electrodynamics and plans for satellite missions like C/NOFS for in-situ measurements and suggestions for collaboration on complementary observational data, (b) the new experiments on UV/optical/IR imaging of ionosphere from polar and geostationary orbit, (c) the highlights of the scientific problems and challenges in the field of magnetic storms/sub-storms and their impacts on magnetosphere-ionosphere coupled systems including ionospheric response during an extreme space weather event and (d) modeling of the solar terrestrial phenomena particularly in terms of improving the predictability of space weather and for use in communication and navigation systems.

## KEY FINDINGS

### Astronomy:

- The United States is the world leader in all branches of space astronomy with cutting-edge technologies to address important problems in astrophysics. On the other hand India has active research groups in X-ray astronomy, IR astronomy with interest in UV astronomy and has proven track record of successfully conducting experiments with space platforms. It is also noted that there exists a large pool of experienced and skilled scientists and engineers and high-quality infrastructure, for the design and development of new detector system and associated hardware and software.

- Keeping the above in mind, the following activities were identified for possible Indo-U.S. collaboration: (i) science data analysis with current U.S. missions and forthcoming Indian ASTROSAT mission, as well as coordinated space- and ground-based observations including exchange of scientists between the two countries, (ii) formulate plans for joint development of new generation detector systems and associated instrumentation for future space missions and validate these from balloon and rocket experiments. (iii) joint plans for developing "Explorer" class missions to

address specific outstanding problems in frontier areas of astrophysics such as: (a) very high resolution X-ray timing studies with suitable large area detector system (b) mission for studies in mid/far infrared astronomy to fill the gap in a band not covered with present observatories, and (c) mission for X-ray polarimetry using new detector concepts.

## Planetary Science:

- The current strength of the planetary science programme in India is laboratory studies of planetary materials to understand the origin and evolution of solar system objects. Collaboration with several U.S. groups already exists and these may be further strengthened through appropriate support. The new Indian initiative on lunar exploration has opened up the possibility of a wide-ranging Indo-U.S. collaboration.

- In view of the above, the following activities are suggested for Indo-U.S. collaboration:

    - Joint Indo-US proposals for future ISRO/NASA planetary missions with shared responsibilities for payload development, data analysis and synthesis

    - Collaborative plans for dedicated planetary missions to the Moon, Mars, Asteroids and comets with emphasis on science objectives using Indian and U.S. launch capabilities.

## Solar-Terrestrial Science

- The wide array of Indian aeronomic facilities such as those for radars, rockets and high-altitude balloons and other ground-based observatories provide a strong network for the study of complex equatorial atmospheric processes. The US has several satellites (currently operational and others ready for launch) that provide aeronomical data streams, which complement the aforementioned ground facilities for resolving long-standing problems in this region.

- The United States has advanced capabilities for designing and developing in-situ, UV and infrared imaging and spectroscopic payloads, which can meet India's burgeoning needs in the space-based communication and navigation arenas. India's high level of system design capability for such advanced satellites can offer cost effective solutions. The right environment needs to be created for enabling such partnerships for the benefit of both nations.

- The diverse data streams emanating from India's sophisticated ground and space observatories need to be assimilated in physics based models of the coupled sun-earth system. The United States has already developed several such sophisticated modeling centers, which can be augmented by data inputs from the Indian region and also can provide a unique opportunity for training Indian scientists in modeling techniques.

## RECOMMENDATIONS

Based on the deliberations during the plenary session and various suggestions by participating scientists from India and the United States the following recommendations are made:

- **Short Term:**

    - Respond to Announcement of Opportunity (AO) for space-based and related experiments
    - Exchange of scientists and engineers
    - Support for inter-institutional programs on topics of mutual interest
    - Sharing of data from scientific missions
    - Coordinated space- and ground-based observations as complementary to space missions, as for example, the upcoming C/NOFS satellite mission

- **Medium Term:**

    - Based on mutual interest, scientists participate actively in pursuit of achieving common science goals for example, using available/jointly developed payloads to be placed in satellite, rocket and balloon platforms, such as the RAIDS and IMAGER instruments, and future Astronomy and Planetary Science missions
    - Augmenting modeling efforts in India in space sciences through collaboration with specialized centers in the United States, of vital importance for atmospheric Science studies and technological systems

- **Long Term:**

    - Jointly conceive space science missions in niche areas of mutual interest from conceptual level in the areas of space-based astronomy, exploration of the Moon, Mars and solar terrestrial science.

## CONCLUSION

The delegates in the Space Science sessions strongly endorse the above recommendations and suggest that respective space agencies, as for example ISRO and NASA, set up a suitable working group for follow up action and implementation. It is also proposed that a suitable mechanism be evolved for funding collaborative India-United States programs in space sciences.

# SPACE EDUCATION AND TRAINING SYMPOSIUM

Co-Chairs:
B. L. Deekshatulu, ISRO, India
Rosalyn Pertzborn, University of Wisconsin, USA

Rapporteur:
P.S. Roy, IIRS, India

## SYMPOSIUM SUMMARY

Both India and the United States have experienced insufficient numbers of students electing to pursue careers in the spaces sciences and engineering. The commercial space science industry in the United States has reported a lack of incoming science/engineering students, with a majority coming from other nations, who then frequently return to their home countries. India has observed a decrease in the number of young people choosing space science and engineering career tracks, with the additional "brain drain," of her most talented young people upon completion of their undergraduate studies to the United States.

Although cultural contextual conditions and historical circumstances leading to the current status for each nation vary, several key areas have emerged as points of commonality in which joint collaborative efforts should proceed to improve the overall quality of Space education and training for both India and the United States. Several critical requirements must be addressed to adequately address the impending shortage of space science and engineering professionals in both nations: 1) Effective partnerships between space scientists and engineers with the pre-college teaching community as well as undergraduate and graduate university educators is essential to deliver a world-class education for all students in both nations. 2) Proactive industry participation at the pre-college and college level is another key requirement to ensure the adequacy and quality of training across the entire "pipeline." 3) The availability and improved effectiveness of distance education capabilities will become a critical vehicle that will overcome historical limitations based on geographic distances and accessibility for students in the remote regions of both nations as well as urban centers to insure equality in educational opportunity.

Proposed collaborative initiatives include teacher professional development and training, Joint Centers of Excellence in India and the United States in universities and institutes to promote high-quality education, research and training opportunities in space science and technology across the entire education pipeline from pre-college to practicing professionals. The wealth of existing human resources in the world's two greatest democracies presents an unprecedented opportunity to collaboratively advance the space sciences and science education community for the future benefit of humankind.

## KEY FINDINGS

### I. Pre-college Education and Teacher Training

#### A. Short Term: 1–2 Years

**Finding 1:** A diverse interdisciplinary and highly qualified array of professional expertise in earth and space science and education (pre-college, undergraduate, graduate and practicing professionals) is critical for the successful definition and implementation of a collaborative

Indian-U.S. Working Group to facilitate the advancement of space education and training initiatives.

**Recommendation 1:** A core Space Science and Technology Education Team comprised of selected members from both nations should be identified to plan an initial Working Group meeting within six months to one year to explore existing and future programs and collaboration. Relevant experience should encompass scientific research (space and earth science), engineering and education (pre-college and higher education), industry and federal agencies from both nations with interests in positive collaborative space education and training activities.

### B. Medium Term: 2–5 Years

**Finding 2:** Both nations will be unable to strengthen the science/engineering talent pool without adequately trained pre-college science and mathematics teachers. An in-depth understanding of critical content areas is essential for pre-college educators to provide high-quality learning experience that will enable students in succeed in the higher education environment.

**Recommendation 2:** A support network model to effectively partner the scientific and engineering professional communities with pre-service and in-service teachers and colleges of education should be identified in both nations. Several existing models to consider for modeling or expansion include NASA's Office of Space Science program and the GLOBE program.

**Finding 3:** The commercial sectors of both nations must become more actively engaged (including resource commitments) in supporting the improvement of Space Education and training.

**Recommendation 3:** Identify specific opportunities for collaborative partnerships between scientific/engineering professionals, educators and commercial partners to develop Science, Mathematics and Technology Pipeline program implementation models (including authentic independent evaluation for effectiveness) that can be readily adapted for the unique needs and requirements of both India and the United States.

**Finding 4:** There is a critical need to enable education and training opportunities for young women, rural and urban economically disadvantaged groups in both nations who represent a relatively untapped human resource for future space scientists and engineers.

**Recommendation 4:** Both India and the United States must collaborate to create targeted programs that recognize the unique educational needs and requirements for historically underserved communities (women, rural and urban).

### C. Long Term: 5–10 Years

**Finding 5:** "Best practices" and effective models for collaborative partnerships between the space science/engineering/education and industry must be identified through critical evaluation and adaptations of early joint program and activities undertaken by both nations.

**Recommendation 5:** Effective models must be adapted and shared between the two nations through the effective utilization of state-of-the-art distance education vehicles, with the common goal of establishing "International Classrooms Without Boundaries" for space science, technology education and training. The time for collaborative planning and implementation of this infrastructure to link both nations is now!

**II. Higher Education and Continuing Professional Development**

- A diverse interdisciplinary and relevant array of professional expertise in earth and space science education (pre-college, undergraduate, graduate and professionals) is critical for the successful definition and implementation of a collaborative Indian-US Working Group to facilitate the advancement of space education and training initiatives.

- Both nations recognize a need to improve the overall quality and quantity of education and training opportunities in the space sciences, technology and applications.

- Both nations identified the need for innovative pre-college and college education in fundamental subject areas leading students to space science and technology career paths.

- There is critical need for continuing education and distance education programs for teachers and professionals in both nations. Quality, standards-based curriculum and teaching material that emphasize high interest space science topics must be developed.

- There is an urgent need to improve science and technology education and career opportunities for young women, and economically disadvantaged students in rural and urban regions in both nations.

- There is a wide gap in the support of training and education programs by commercial sector in the United States and India.

## RECOMMENDATIONS

**(A) 1–3 Years:**

1. Establish and support joint centers of excellence in Indian universities.
2. Methods of support to sustain existing institutions and programs such as at CSSTEAP UN and the WMO's Global Education and Science Network (GESN), GLOBE schools. Examples:
    - Establishment of fellowships for the CSSTEAP course participants
    - Visiting faculty/staff to CSSTEAP (short/long)
        - Faculty and student exchange
    - Specialized training programs, equipment and infrastructure.
3. Suggested areas of collaboration for education and research:
    - Education and research in Earth system science (oceans, atmosphere, and surface) and Sun-Earth connection.
        - Weather and climate
            - Instrumentation, observation, and modeling
            - Disaster prediction/forecasting
    - Human-ecosystem-climate interactions
    - Decision support system for global spatial data infrastructure
    - GPS applications
    - Teacher training programs in Earth and space Science for K-16 communities

4. Pre-college education in the fundamental subjects related to space sciences and technology must be strengthened in both countries to inspire the future generation to pursue career in these areas.
5. The commercial sector, in both countries, must become more actively engaged (including resource commitment) in supporting science education and training.

**(B) 3–5 Years:**

6. Tele-education (U.S. lessons with EduSat experience in teaching on technical, medical, and disaster management)
7. Planetary and space science
8. Geological sciences
    - Mining exploration
    - 3D GIS and remote sensing (LIDAR, microwave, infrared interferometry)
    - Modelling and visualization of geological processes.
    - Mineral suite and hydrocarbon habitat mapping

# SPACE COMMERCE PLENARY: CHALLENGES AND OPPORTUNITIES FOR EXPANDED SPACE COMMERCE AND BUSINESS

Co-Chairs:
K. R. Sridhara Murthi, Executive Director, Antrix Corporation, India
Ingrid Belton, Director–Trade Policy, U.S.-India Business Council, USA
Michael T. Clark, Executive Director, U.S.-India Business Council, USA (preparation)

Rapporteur:
T. S. Shobha, Antrix Corporation, India

## PLENARY SUMMARY

A general commerce plenary session with representatives from U.S. and Indian industry was held in conjunction to the India-United States Conference on Space Science, Applications and Commerce. The overall theme was that space triggers commerce and generates win-win opportunities. To succeed, it is important that industry match the technology for the market. Several of the U.S. and Indian panelists discussed their successful partnerships with each other, in several cases spanning over a decade. All of the panelists stated their desire for increased commercial cooperation for mutual benefit and identified numerous future possibilities. The main outcome of this session was the concern that there are still certain government policies, which significantly block cooperation, particularly in sensitive technology areas.

## KEY FINDINGS

1. U.S. industry stated that India's vertical integration at a grassroots level, which provides familiarity with every aspect of the product, is the most impressive.
2. India's highly educated workforce and significant marketplace is a key advantage.
3. Working with India will offer comparative advantage by bringing down the costs and allowing industry to be more competitive.
4. Indian industry credited the United States with bringing more technological, financial and project management resources to the partnership.
5. U.S. and Indian industry see dual-use export controls in the United States as a hindrance to increased commercial cooperation. [Note: As Under Secretary Juster pointed out, this is now more a problem of perception than reality.]
6. Indian industry stated that there is a need for predictability, reliability of supply, and timeliness of the licensing process.
7. It was suggested that the Indian market offers enough space for effective Indo-U.S. collaboration, where the industries from both size could capitalize on each other's strengths, as exemplified by the Indian IT industry, where the collaboration has been largely successful.
8. U.S. and Indian industry should work together to address the Earth Observation market and value added services market.
9. U.S. industry suggested that India's value added industry sector adopt GIS guidelines and standardization in the mapping areas.
10. There are significant opportunities for global positioning, geo-synchronous systems, remote sensing data and navigational applications.
11. In the area of social concerns, telemedicine and education are key developmental areas.

12. Industry is waiting to see success vis-à-vis the government-to-government dialogues on space. Many firms have been reluctant to submit licenses under the assumption that these licenses will be denied.
13. Confidence-building measures must be demonstrated to increase industry interest.

## KEY RECOMMENDATIONS

### Short Term

1. Continue discussion of space-related issues at the U.S.-India High Technology Cooperation Group (HTCG). The U.S.-India Business Council and the appropriate industry organization from the Indian side will write to our respective governments requesting that they consider this recommendation. The next meeting of the HTCG is expected to occur in October or November 2004. [Note: Space-related issues, particularly as they relate to export controls, have already been discussed at the HTCG.]
2. Request a review and a refinement of the existing export control policies and trade barriers in both the United States and India. A meeting will be organized by U.S. and Indian industry to discuss and formulate a letter to be presented to our respective governments. The letter will be sent by end-July 2004.
3. Review existing models for joint manufacturing of satellites. Examples will be provided by U.S. industry. An example provided was Loral and Alcatel (France) for Intelsat mission. The U.S.-India Business Council, the Aerospace Industries Association, and the Space Enterprise Council will contact their member companies to request similar detailed examples. This information will be assembled by end-July 2004.
4. Organize a briefing with export control officials from our respective governments to provide an overview of current government policies regarding commercial space cooperation. The U.S.-India Business Council will request a meeting from officials at the U.S. Department of Commerce and the Department of State. The appropriate industry forum from the Indian side will organize a similar meeting with the relevant Indian officials. The U.S. meeting is targeted for early-August 2004.

### Medium Term

1. There are numerous opportunities for U.S. companies in the area of satellite transponders in the Indian market. Our industries must have further discussions to explore the possibilities of working jointly in this segment
2. Create a conducive environment to facilitate mutual sharing of the satellite services market, including launch and mission support services.

## CONCLUSION

It is important now to test this new relationship and secure successful ventures. An effort is also required to educate and inform our policy-makers in both countries regarding the importance of this relationship. Cooperation between the private sector, academia, research institutions and the government is vital to success. Industry recognizes that differences do still exist between our two countries, but there is certainly a realization that there is far more that unites us than divides us.

# PUBLIC OUTREACH TALKS

# PUBLIC OUTREACH TALKS

Three important public outreach sessions were organized during the India-United States Conference on Space Science, Applications and Commerce. The Public Outreach evening session drew, apart from the delegates, media and interested personalities from various walks of life from Bangalore.

**June 22, 2004: Dr. K. Kasturirangan, Member of Parliament (Rajya Sabha) and Director, National Institute of Advanced Studies, Bangalore (Formerly Chairman of ISRO)**

Dr. K. Kasturirangan, Member of Parliament, in his talk "Indian US Space Cooperation — A Ringside Perspective," highlighted that the future of India-U.S. space cooperation is to be built around ideals of spirit of exploration; humanitarian outlook; ensuring global environmental integrity; societal upliftment and deriving economic benefits. Dr. Kasturirangan strongly advocated better cooperation and unified efforts to eradicate social evils such as illiteracy, health care and better management of natural resources — not just in the two nations but in a mission approach across the globe. He mentioned that the potential areas for India and the United States to work together could be in possible joint missions in the areas of education, health, disaster management, space science and remote sensing for mutual and global benefit. In the education sector, he said, India and the United States can have joint satellite missions that can be the core infrastructure for providing education services in different nations — at school, university and professional training levels. He also envisioned the use of space technology for addressing health-care requirements — as satellites could provide the outreach for specialists and modern hospitals, that are mainly in urban areas, to rural areas of the world. Here too, he felt that India and the United States could address joint missions and also carry on the experience that each nation had to the betterment of many nations of the world. The third area highlighted by Dr. Kasturirangan was in support of Disaster Management where an integrated observation system approach could pave the way for an international capability in responding to disasters. He mentioned that in the area of remote sensing, both nations could work together to develop value-added solutions for the globe; use of GIS and enabling spatial databases; establishment of joint applications centres in other nations and even developing joint EO missions in the government and commercial sector.

**June 23, 2004: Astronauts Session with Ms. Sandra Magnus and Mr. J.P. Harrison**

In a very interesting session of interaction with U.S. astronauts, the delegates and invitees enjoyed the interaction with Dr. J. P. Harrison and Dr. Sandra Magnus.

J. P. Harrison enthralled the audience by giving a detailed account of Kalpana Chawla's life and achievements. The spirit of the new generation and their enthusiastic response gave credence to the adventurous spirit of Kalpana Chawla. Kalpana was an independent child and struggled to achieve her goal to become an aerospace engineer. She did her Ph.D. programme at the University of Colorado and dreamt of becoming an astronaut. She finished her Ph.D. studies in 1988 and received her pilot license. In 1992, she applied to be an astronaut and in 1994 she was selected for the astronaut programme. In 1995 she moved to Houston and started her astronaut training. STS-87 was her first flight and during that flight she spoke with Indian Prime Minister Mr. I. K. Gujral from space. In 2000, she again started training to go in the shuttle to space. Chawla lost her life during the unfortunate accident of the Space Shuttle Columbia on 1 February 2003.

Magnus said that Kalpana was a great example of an exploring personality. Being an

astronaut is the best opportunity for any explorer. Speaking about the great explorations undertaken by mankind, she pointed to Antarctica, where there are no human borders, and similarly to space — where India and the United States are playing key roles in scientific explorations. With the advancements of technology, the world has become a "small place." But now we are asking more fundamental questions, such as why and how are we in this universe; are there other life forms; how can we explore the outer planets and the universe. Many nations have had space programmes and India is recognized as one of the leading nations in space. The initial space exploration target was the Moon. In their race to the Moon, The United States and the Soviet Union launched many missions — some that were successful and some that were not. Now, we have landed on other planets and the new rover missions are providing great insights into Mars and expanding our horizon.

**June 24, 2004: Prof. U. R. Rao, Chairman, PRL Council (Formerly Chairman of ISRO)**

Prof. U. R. Rao said that a new chapter has begun in Indo-U.S. relations. He called for humanization of globalization as it had adverse effects on developing countries. He also said that if India and the United States collaborate in space the world would shine. He mentioned that Indians are playing a major role in the U.S. economy and technological achievements and the partnership needs more formalization. India and the United States can cooperate in a number of areas such as ensuring food security, education, health, disaster management, economic and national security areas. Integrating technologies and developing solutions for the betterment of the world is called for. He mentioned that Indian capabilities in applications of space for addressing national development perspectives could be a model for many other developing nations to adapt. Furthermore, U.S. technological capability could bring solutions that can enable nations to benefit from space.

# SPECIAL EVENT:
# ADDRESS BY HIS EXCELLENCY DR. A.P.J. ABDUL KALAM, HONORABLE PRESIDENT OF INDIA
## (THROUGH A SATELLITE BRIDGE WITH DELHI)

## ADDRESS BY HIS EXCELLENCY DR. A.P.J. ABDUL KALAM, HONORABLE PRESIDENT OF INDIA (THROUGH A SATELLITE BRIDGE WITH DELHI)

## DYNAMICS OF INDO-U.S. SPACE CO-OPERATION

The President made a detailed presentation on “Dynamics of Indo-U.S. Space Cooperation” and highlighted the following issues where India and the United States could consider working together:

- Commencement of Indo-US space cooperation in Thumba, which started four decades ago. The work of two teams dealing with scientific payloads and the other dealing with rocket, payload and system integration resulted in a beautiful successful experiment with the cooperation of three nations — India, the United States, and France.
- Enriched experiences so far of both India and the United States in furthering and advancing space technology for benefiting society. He mentioned about India’s proposed Moon mission and project on Reusable Launch Vehicle (RLV). He also noted U.S. success in Mars rovers and the recent scramjet engine testing.
- Challenge before both India and the United States — especially in satellite communications, remote sensing and launch vehicles. He mentioned that two technologies are unfurling and needed further investigation — the reusable technology with multiple launching capabilities and nanotechnology.
- Cost of access to space, which needs to be reduced by several orders of magnitude and could enable the global space community to move out of the present era of information collection missions into an era of mass movement missions.
- Cost reduction strategies requiring a global effort to quickly demonstrate the technology for low-cost access to space.
- Development of reusable launch system and proving of the hyper-plane concept, on which both the United States and India were working, could reduce cost of access to space forbids further expansion of space activities. Therefore, it is an opportune moment for India and the United States to work together and launch a major universal mission to share the benefit of space with the whole of mankind.
- Need for a long-term perspective and global space missions. Need for a long-term 50-year perspective from small-scale technology demonstrations of re-usable launch vehicles through solar power satellite demonstrations and satellite constellations to heavy lift RLVs for large scale solar power satellites, space manufacturing and ultimately to space habitat and extra terrestrial mining.
- Integrating space, information, nano- and bio-technology for societal transformation and for innovative missions that must address proactively acute problems of rapid depletion of conventional energy sources, drinking water supplies, and deliver solutions for the man-planet conflict that has led to pollution, climatic change and degradation of ecology and the environment.
- Integrated approach to nanoscale structures that would need an integrated approach of nano-science, nanotechnology, applications and nano-manufacturing leading to its impact to the society.
- Earthquake prediction — need to mount a joint research programme for evolving a systematic methodology for determining the effects leading to earthquakes.
- Forty years looking back and forward from now. The President stressed the need to look beyond and develop a strategic approach. it is important that two big democracies of the world have to think how the space science technology and commerce can bring about global economic prosperity and global peace. Can space technology and applications effectively contribute towards peace mission?

The President suggested a five-point space missions for the consideration by Indo-U.S. space community:

1. Bring down the cost per kg launch of payload. This can be done only with the use of reusable technology with oxidizer generation during the flight by mass addition and use of new materials.
2. Spacecraft weight should be brought down substantially using nanotechnology in composite structures, electronics, computing and protective coating. This reduction in launch weight will add to the payload.
3. Intensive partnership between the two countries for generating power using SPS and the space exploration, particularly mining of minerals by space industries from the Moon, asteroids and establishment of first habitats in Mars.
4. In a 10-year period, NASA and Indian space scientists and technologists in collaboration with geologists of respective countries will be capable of predicting earthquake at least a week ahead, similar to cyclone prediction now. It will need intensive research in the area of geo-magnetics and related instrumentation.
5. The benefits of space research should reach the six-billion-person population by providing them with unhindered supply of safe drinking water, shelter, food, health care and education so that we will have a peaceful, happy and prosperous world.

The President interacted with the delegates of the Conference in Bangalore and answered questions raised by many U.S. and Indian delegates.

# CLOSING PLENARY

# CLOSING PLENARY: FUTURE DIRECTION OF INDIA-U.S. COOPERATION AND COMMERCE

Co-Chairs:

P. S. Goel, Director, ISAC, ISRO, India
Lee M. Morin, Deputy Assistant Secretary of State, USA

Rapporteurs:

Mukund Rao, DD (NRR), ISRO, India
Mireille Gerard, AIAA, USA

## PLENARY SUMMARY

The reports of the different Symposium were presented in the closing plenary, as follows:

- Report of Earth Observation Symposium was presented by Dr. R. R. Navalgund
- Report of the Satellite Communications Symposium was presented by Mr. A. Bhaskaranarayana
- Report of the Space Science Symposium was presented by Dr. George Joseph
- Report of the Satellite Navigation Symposium was presented by Mr. Stephen Moran
- Report of the Space Education and Training Symposium was presented by Dr. Rosalyn Pertzborn
- Report of the Space Commerce Plenary was presented by Mr. K. R. Sridhara Murthi

Dr. P. S. Goel expressed optimism at the Conference outcome and said scientific collaboration and commerce activities should get a boost. The Conference has opened new avenues for cooperation and has helped achieve a major goal of better understanding between the two nations. He hoped that the two governments would now re-assess priorities and commit to collaborate develop mutually beneficial partnerships. He mentioned that potential for collaboration exists in many areas and also a possibility of commerce. In commercial activities, India could help in cost-leveraging to U.S. industry by undertaking joint development projects. He mentioned that government agencies, industries and academia of both nations had shown great interest in working together — as was seen in the conference what was needed was the right environment to be created in the two nations so that visible outcome of cooperation could be seen. He noted that the Conference had achieved its objectives and had identified areas for cooperation and the onus was now on the two governments to take forward the vision that this Conference identified.

Dr. Lee Morin highlighted a theme that recurred throughout the conference: we stand to gain more from working together than we can possibly gain by working on our own. He observed that the conference had contributed significantly toward building the good will needed to work together toward common goals. To carry these efforts forward, he suggested that organizations identify high-priority recommendations with the greatest likelihood of success while working persistently to resolve problems with existing cooperation so that we could build a record of successful cooperation. He remarked that cooperation on earth, unlike projects in space, cannot operate in a vacuum, making it important to bring into the process all with a stake in space-related cooperation and to ensure that space issues are taken into consideration in other policy areas. In this light, he noted that determined progress on the Next Steps in Strategic Progress would allow enhanced cooperation in many areas discussed in the conference. He urged both sides to look for opportunities to actively cooperate on multilateral efforts and in international fora, especially in building a Global

Earth Observation System of Systems.

Ms. Meera Shankar, MEA struck a positive note and mentioned that the area of high-technology commerce between the two nations had tremendous potential to be explored — especially considering the past 40 years of cooperation activities behind the two nations. There could be a natural synergy between both countries in this sector of commerce. Looking at the figure of high-technology commerce, even with the lifting of sanctions by the United States, the number of applications for license may be high but the volume and value of trade is still very low ($37 million to $57 million $ over the past years). It looks like that on the basis of presumption of denial, license applications are not being made, which should reflect in higher and growing volumes of trade. She stressed the need to look at high-technology commerce in a practical way and emphasizing more on the civilian and social benefits such as in areas of satellite communications and remote sensing. India has always emphasized the social relevance of its space activities — for education, health, public broadcasting, telecom connectivity and so on. She also mentioned the other area of telecom services in India, which have had a virtual explosion of services and overtaken many other countries, thus creating a big market segment and demand. We see further growth in telecom industry with the sheer quantity of unexplored territories. There was emphasis on developing the standards and educational facilities of our rural areas and using technology to achieve it. Further, India could be an R&D hub. It could leverage the knowledge base in India and the production demands of U.S. industry. Thus, there is plenty of potential for U.S. participation and contribution so that both nations could benefit. She envisioned the Conference as a start of a new process and stressed that both sides must work at making the projects and recommendations of this Conference into a reality.

Dr. Don Anderson, NASA, observed that dynamic changes in technology are improving tremendously our capability to acquire and observe, assimilate and integrate different data sets to offer enhanced and higher quality services through space. Each side had capabilities that could be contributed to benefit each other's programmes. The information exchanged during this conference had been phenomenal. He hoped that the bilateral discussion and collaboration in the Conference would smoothe the data and technology exchange and management of programs between the two nations. The involvement of decision makers from both sides had made the conference very fruitful. He also discussed the NASA restructuring announced on June 24, 2004.

Mr. A.M. Powell, NOAA, expressed gratitude to all the people involved in this conference for their cooperation, energy, and hospitality in bringing about this important opportunity to collaborate. He said that the Conference had set reachable goals and recommendations — especially through the Symposia. Several levels of participation could now be identified — namely grassroots participation at individual/scientist level for specific projects; organizational level interaction for missions/programmes and national level for major programmes. From the NOAA perspective, he highlighted the Global Earth Observing System of Systems (GEOSS), where 47 nations are participating, as a potential area where India and the United States could play a major role. Other areas holding out promise included NPOESS data acquisition and utilization, and meteorological data exchange. He also mentioned that NOAA is an operational organization that services global needs with products supporting an estimated $3 billion industry. He hoped that more widespread use of the products, allowing cost reduction and improving efficiency, could be achieved through mutual cooperation.

## RECOMMENDATIONS: VISION STATEMENT

The Vision Statement of the Conference, drafted and discussed by participants on both

sides in consultation with the co-chairs of the symposia and sessions, Programme Committee and others, was presented and adopted by acclamation during the closing plenary.

## VALEDICTORY SESSION

Mr. Mukund Rao and Ms. Mireille Gerard jointly delivered the statement of the co-chairs of the Programme Committee. In a tandem manner, they traced the evolution of the Conference and highlighted the steps taken in planning and developing the Conference programme. They also thanked the Programme Committee and others involved in the Programme, especially Dr. J.V. Thomas, for their valuable support in making the programme so successful. They were confident that a good beginning had been made with the Conference outcome and expressed hope that the two governments and other organizations would further joint cooperation through concrete steps on the recommendations. Finally, they submitted the final Vision Statement of the Conference and requested Dr. Goel to formally hand over the Vision Statement.

By a show of acclamation, the Vision Statement was commended to the two Governments. Dr. Goel presented the Vision Statement to Mr. G. Madhavan Nair, as the representative of the Indian Government, and Dr. Lee Morin, as the representative of the U.S. Government.

Mr. Nair and Dr. Morin accepted the Vision Statement for consideration in their respective efforts to advance bilateral civil space cooperation.

Mr. V. Sundararamaiah, Scientific Secretary, ISRO proposed formal thanks. He mentioned that new partnerships had been built and called for the need to work ahead and further renew them through interactions and contacts. He observed that the 550 delegates not only gave credence to the spirit of cooperation and working together but also enthused both sides with the participation and interaction.


Astronautical Society of India


American Institute of Aeronautics & Astronautics

# VISION STATEMENT

**India-United States Conference on**
**Space Science, Applications and Commerce —**
**Strengthening and Expanding Cooperation**

**June 21–25, 2004**
**Bangalore, India**

# INDIA-UNITED STATES CONFERENCE ON SPACE SCIENCE, APPLICATIONS AND COMMERCE — STRENGTHENING AND EXPANDING COOPERATION

## VISION STATEMENT

NOTING that the Republic of India and the United States of America share a history of four decades of cooperation in civil space activities;

RECOGNIZING that the achievements in space of the United States and its sustained commitment to space exploration have advanced scientific understanding; stimulated public interest in space exploration, science, technology and applications; and demonstrated vividly that humankind can benefit from space;

RECOGNIZING that India's space programme has evolved from its early steps of exploration to an important and advanced scientific, technological and business endeavor, oriented towards the developmental needs of the country and its sustainable economic growth, with significant potential for international cooperation;

NOTING that the Joint Statement between the United States of America and the Republic of India of November 2001 expressed the commitment by the President of United States and the Prime Minister of India to broaden dialogue and cooperation in civil space activities and to discuss ways to stimulate high technology commerce between the two countries; and

NOTING the statements by the President of the United States and the Prime Minister of India in January 2004 announcing the Next Steps in Strategic Partnership with India to expand cooperation in civilian nuclear activities, civilian space programs and high-technology trade, and to expand their dialogue on missile defense;

WELCOMING the INDIA-UNITED STATES CONFERENCE ON SPACE SCIENCE, APPLICATIONS AND COMMERCE — STRENGTHENING AND EXPANDING COOPERATION as an opportunity to carry these initiatives forward;

TAKING COGNISANCE of the deliberations of the Conference, held in Bangalore on June 21-25, 2004;

The space communities of the United States and India, in the Closing Plenary of the Conference, hereby offer the following Vision for enhanced cooperation between the two countries to their governments, business enterprises and research institutions for their consideration and appropriate action:

1. Both the United States and India have tremendous capability and capacity in space science, technology and applications. Through scientific and technological cooperation and farsighted commercial endeavors, and in an appropriate policy and business environment, these assets can be leveraged to the benefit of both nations and contribute to sustainable global economic growth and scientific advancement.

2. Areas with strong potential for enhanced cooperation in civil space research and other activities between India and United States, as discussed in the Conference, include:

    a. Earth Observation Science, Technology and related Applications — including natural resources management, meteorology, water cycle, atmospheric sciences, infrastructure etc
    b. Satellite Communications Technology and Applications — including tele-medicine, tele-education etc
    c. Satellite Navigation and Applications
    d. Earth and Space Science — including Astronomy, Planetary Science and Solar-Terrestrial science etc
    e. Natural Hazards Research and Disaster Management Support
    f. Education and Training in Space

    Details of possible areas of cooperation are contained in the reports by the Symposia Co-Chairs.

3. In the commercial sector, aerospace enterprises from India and the United States can profitably explore promising opportunities for business development in the areas of Earth Observations, Satellite Communications and Satellite Navigation through possible collaborative business ventures serving national and global markets. These business opportunities are also outlined in the reports by the Symposia Co-Chairs.

4. Supportive policy and business environments in India and the United States will facilitate enhanced civil space cooperation and encourage active networking among government agencies, private enterprises, and academic and research institutions to the benefit of both nations and the world. Efforts by both governments to strengthen the bilateral relationship, address policy issues and facilitate commerce are welcome.

5. Efforts begun at this Conference should be continued. Cooperation and commerce between the two nations in the area of civil space could be facilitated through a high-level mechanism involving key representatives of government, business, academic and other non-governmental organizations from the United States and India. Under the leadership of the Ambassador of the United States to India and Chairman of the Indian Space Research Organisation, meetings at appropriate intervals could enable the mechanism to monitor and review progress on civil space collaboration between the two countries.

6. In addition, the contact points in key organizations and other forms of networking recommended by the Conference Symposia can usefully serve to address issues as they arise in order to ensure that the enhanced cooperation envisioned by this Conference will be realized.

Adopted on June 25, 2004 by the participants in the INDIA-UNITED STATES CONFERENCE ON SPACE SCIENCE, APPLICATIONS AND COMMERCE — STRENGTHENING AND EXPANDING COOPERATION.

## SPACE EXHIBITION

An excellent Exhibition was organized by M/s MMActiv, Pune, India, on the lawn of Hotel Ashok. The Exhibition was inaugurated jointly by Mr. G. Madhavan Nair, Chairman, ISRO and President, ASI, and Mr. Kenneth I. Juster, U.S. Under Secretary of Commerce on June 22, 2004. The following organizations participated in the Exhibition:

| EXHIBITING AGENCIES | Website Address |
|---|---|
| AEROSPACE & MARINE INTERNATIONAL | www.kpnl.net |
| AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS (AIAA) | www.aiaa.org |
| AP NET INFORMATION TECHNOLOGY & COMMUNICATIONS DEPARTMENT, (GOVERNMENT OF ANDHRA PRADESH) | www.ap.gov.in |
| ARITHNET TECHNICAL SERVICES PVT. Ltd | www.atssoft.com |
| BHARAT ELECTRONICS LIMITED | www.bel-india.com |
| THE BOEING COMPANY | www.boeing.com |
| CENTRE FOR DEVELOPMENT OF ADVANCED COMPUTING | www.cdacindia.com |
| CONNEKT ELECTRONICS PVT. LTD. | www.touchtelindia.net |
| ERDAS INDIA PVT. LTD. | www.erdasindia.com |
| EICHER GOODEARTH LIMITED | www.eicher.co.in |
| GIS DEVELOPMENT | www.gisdevelopment.net |
| GODREJ & BOYCE MFG. COMPANY LTD. | www.godrej.com |
| HINDUSTAN AERONAUTICS LIMITED | www.hal-india.com |
| HONEYWELL INTERNATIONAL (I) Pvt. Ltd. | www.honeywell.com |
| INDIA METEOROLOGICAL DEPARTMENT, GOI. | www.imd.ernet.in |
| INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SEVICES | www.incois.gov.in |
| ISRO, ANTRIX, NRSA | www.isro.org<br>www.antrix.org<br>www.nrsa.gov |
| KARNATAKA STATE REMOTE SENSING APPLICATIONS CENTRE | www.bangaloreit.com |
| LARSEN & TOUBRO LTD | www.ltindia.com |
| NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) | www.nasa.gov |
| NATIONAL AEROSPACE LABORATORIES | www.cmmacs.ernet.in/nal/ |
| NATIONAL OCEANIC AND ATMOSPHERIC ASSOCIATION (NOAA) | www.noaa.gov |
| NIIT GIS LIMITED (ESRI INDIA) | www.niit.com |
| NORTHROP GRUMMAN CORPORATION | www.ngc.com |
| ORIENT FLIGHTS (P) Ltd. | |
| OVERLAND STORAGE INC. | www.overlandstorage.com |
| PUNJAB REMOTE SENSING CENTRE | |
| RAYTHEON COMPANY | www.raytheon.com |
| SPACE IMAGING LLC | www.spaceimaging.com |
| SPECK SYSTEMS LIMITED | www.specksystems.com |

| | |
|---|---|
| TATA CONSULTANCY SERVICES | www.tcs.com |
| TELEVITAL (INDIA) PRIVATE LIMITED | www.televital.com |
| TRIMBLE NAVIGATION | www.trimble.com |
| UMAC AVIONICS PVT. LTD. | www.umacavionics.com |
| UNITED STATES GLOBAL POSITIONING SYSTEM | |
| VIASAT INC | www.viasat.com |

The Exhibition was a major attraction in the city of Bangalore and a large number of people visited the Exhibition during the Conference.

# CONFERENCE ORGANIZATION TEAM

**INDO-U.S. JOINT STEERING COMMITTEE**

**CO-CHAIRS:**

G. Madhavan Nair, Chairman, ISRO/Secretary, DOS
V. S. Ramamurthy, Secretary, DST/Indian Co-Chair IUSSTF
Paula Dobriansky, Under Secretary for Global Affairs, U.S. Department of State
Kenneth I. Juster, Under Secretary, U.S. Department of Commerce
Conrad Lautenbacher, Administrator, NOAA and Under Secretary of Commerce for Oceans and Atmosphere
Sean O'Keefe, Administrator, NASA

INDIAN REPRESENTATIVES:
Radha Singh, Secretary, Ministry of Agriculture, Government of India
M. Shankar, Secretary, Department of Land Resources, Government of India
K. K. Jaswal, Secretary, Department of Information Technology, Government of India
A. K. Goswami, Secretary, Ministry of Water Resources, Government of India
K. Roy Paul, Secretary, Ministry of Civil Aviation
N. N. Khanna, Secretary, Ministry of Urban Development, Government of India
P. Ghosh, Secretary, Ministry of Environment, Government of India
Pawan Chopra, Secretary, Ministry of Information and Broadcasting, Government of India
N. K. Bhan, Secretary, Department of Biotechnology, Government of India
Harsh Gupta, Secretary, Department of Ocean Development, Government of India
Vinod Vaish, Secretary, Department of Telecommunications, Government of India
J. V. R. Prasada Rao, Secretary, Department of Health, Government of India
C. D. Arha, Secretary, Ministry of Mines, Government of India
Shashank, Foreign Secretary, Ministry of External Affairs, Government of India
B. S. Patil, Chief Secretary, Government of Karnataka
Jamshyd Godrej, Chairman, Godrej and Boyce Industries
Tarun Das, Director General, Confederation of Indian Industry
H. P. Dikshit, Vice-Chancellor, Indira Gandhi National Open University
P. S. Goel, Director, ISAC and Chair of Indian NAC
Devi Shetty, Leading Heart Surgeon of India
R. S. Bhatia, ITLU, Washington (ISRO Coordinator in U.S.)
V Sundararamaiah, Scientific Secretary, ISRO/ Treasurer, ASI
R. K. Rajangam, Executive Secretary, ASI
A. Mitra, Administrator Indo-US S&T Forum, DST
Mukund Rao, Deputy Director (NRR), EOS, ISRO HQ

U.S. REPRESENTATIVES:
Ralph L. Braibanti, Director, Space and Advanced Technology Staff, Department of State
Michael T. Clark, Executive Director, U.S. India Business Council
Marco Di Capua, Counselor for Science, U.S. Embassy, New Delhi
Frederick D. Gregory, Deputy Administrator, NASA
Kenneth I. Juster, Under Secretary for Industry and Security, Department of Commerce
Brigadier General John J. Kelly, Jr., (USAF. Ret.), Deputy Under Secretary of Commerce for Oceans and Atmosphere, NOAA
Lee M.Morin, Deputy Assistant Secretary for Health, Space and Science, Department of State
Norman P. Neureiter, Co-Chair, Indo-U.S. Science and Technology Forum
Donald W. Richardson, President, AIAA
Michael E. Shaw, Director, Navigation and Spectrum Policy, Department of Transportation

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K. N. Shankara, Director, SAC
B. N. Suresh, Director, VSSC
S. K. Das, Additional Secretary, DOS
V. Sundararamaiah, Scientific Secretary, ISRO/Treasurer, ASI
K. Narayana, Director, SDSC
N. Vedachalam, Director, LPSC
R. R. Navalgund, Director, NRSA
A. Bhaskarnarayana, Director, SCPO
V. Jayaraman, Director, EOS
D. Narayana Moorthi, Director, LVPO
R. K. Rajangam, Executive Secretary, ASI
S. K. Srivastava, Director-General, India Meteorological Department
Prithvish Nag, Surveyor General of India
K. R. Sridhara Murthi, Executive Director, Antrix Corporation
Mukund Rao, Deputy Director (NRR), EOS, ISRO HQ

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Sunanda Basu, Research Professor, Boston University
Michael Cheetham, Administrator, Indo-U.S. S&T Forum
Mireille Gerard, Senior Advisor, AIAA
Kenneth Hodgkins, Deputy Director, Space and Advanced Technology Staff, Department of State
Angelo M. Iasiello, Director, International Business, AIAA
Al Condes, Deputy Assistant Administrator, Office of External Relations, NASA
Alfred M. Powell, Jr., Deputy Director, Office of Research and Applications, NOAA/NESDIS
David L. Ryan, President, Boeing Satellite System International
Megan E. Scheidt, International Program Specialist, AIAA
David A. Turner, Director, Interagency GPS Executive Secretariat, Department of Commerce
Mark Webber, Special Assistant to the Assistant Secretary for Export Administration, Department of Commerce
Robert R. Winship, Space and Advanced Technology Staff, Department of State
Gregory Withee, Assistant Administrator, NOAA

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Mireille Gerard, Senior Advisor, AIAA – Committee Co-Chair
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Mara Browne, International Relations Specialist, NOAA
Supriya Chakrabarti, Director, Center for Space Physics, Boston University
Keya Chatterjee, International Program Specialist, Office of External Relations, NASA
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Fernando R. Echavarria, Space and Advanced Technology, U.S. Department of State

Anish Goel, Office of South Asian Regional Affairs, U.S. Department of State
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Felix Kogan, Physical Scientist, NOAA
Shobha Kondragunta, Physical Research Scientist, NOAA
Ajay Kuntamukkala, Office of the Under Secretary, U.S. Department of Commerce
Stephen G. Moran, Director, Civil Space Programs, Raytheon Company
Bruce Mahone, Director, Space Policy, AIAA, Inc.
Rosalyn Pertzborn, Director, Office of Space Science Education, University of Wisconsin-Madison
Megan E. Scheidt, International Program Specialist, AIAA
Jim Simpson, Vice President, Boeing Satellite System, Inc.
Craig Tiedman, Office of External Relations, NASA
Kelly Turner, Office of the Under Secretary, NOAA, U.S. Department of Commerce
Robert R. Winship, Space and Advanced Technology Staff, U.S. Department of State
Eva Zanzerkia, Program Analyst, Office of Earth Science, NASA

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Angelo Iasiello, Director, International, AIAA – Committee Co-Chair
S. K. Das, Additional Secretary, DOS
M. N. Satyanarayana, Executive Director (Space Industry Development), ISRO
S. S. Balakrishnan, Deputy Director, LVPO
R. K. Rajangam, Executive Secretary, ASI
V. S. Hegde, Deputy Director (A), EOS, ISRO-HQ
R. Venkatramu, Antrix Corporation
Sue Baumgarten, Vice President, Raytheon Company
Ingrid Belton, Director, Trade Policy, U.S. India Business Council
Michael T. Clark, Executive Director, U.S. India Business Council
Maureen Heath, Vice President, Northop Grumman Space Technology
David L. Ryan, President, Boeing Satellite Systems International
Hugh Tulloch, Honeywell Corporation

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V.S. Hegde, Dy Director (A), EOS
S. Krishnamurthy, Director, P&PR, ISRO
Shankar Subramanyam, GM – MPMC, SDCS
K.S. Ramachandra, Dy Secretary, DOS
Air Marshal T. Osman, CII
V. Kunhiraman, Head, P&GA, ISRO

# Glympses of the Conference….

Mr. Prithviraj Chavan, Honorable Minister for state in Prime Ministers Office inaugurating the conference

Dignitaries on the Dais during the inaugural function


Mr. Prithviraj Chavan, Honorable Minister for state in Prime Ministers Office giving inaugural speech; Dr. David C. Mulford, Ambassoador of United states to India and Mr. Kenneth I Juster, Undersecretary of commerce, USA address the gathering

Mr. Madhavan Nair, Chairman ISRO/ President ASI; Mr. John J. Kelly, Deputy UnderSecretary of Commerce for Oceans and atmosphere, NOAA, USA; Mr. Frederick D Gregory, Deputy Administrator, NASA, USA address the gathering

The distinguished delegates as audience during the inaugural function

Mr. Kenneth I Juster, Undersecretary of commerce, USA inaugurating the Space Expo 2004


Mr. Felix Kogan, NOAA, USA explaining the NOASA exhibits

Indian Space Research organization pavilion at the Space Expo 2004


Hindustan Aeronautics Limited (HAL) pavilion.


Opening Plenary panelists on the Dais

Poster session during the conference



Public Outreach speakers: (from left) Dr. K Kasturirangan, Former ISRO Chairman/Member Rajya Sabha; Dr. UR Rao, Former ISRO Chairman/Chairman, PRL Council; Dr. Sandra Magnus and Dr. JP Harrison, US Astronauts



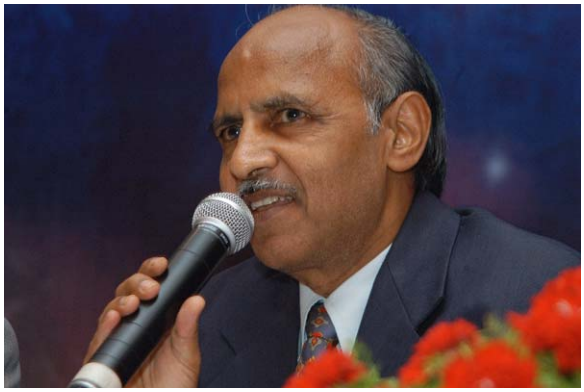
Technical sessions in progress….

Dr. APJ abdul Kalam, Honourable President of India interacting with the audience through a sateelite bridge from Delhi


Closing Plenary panelists on the Dais

A view of the Audience during the technical sessions


Dr. Lee Morin, Deputy Assistant secretary of State, USA address the delegates during closing Plenary



Dr. PS. Goel, Director, ISAC, ISRO/Chairman Indian National Advisory committee Address the gathering

Mr. Mukund Rao and Ms. Mireille Gerard, delivering the statement of the co-chairs of the Programme Committee

Mr. V Sundararamaiah, scientific secretary, ISRO proposing the vote of Thanks